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NATIONAL DAM SAFETY PROGRAM. NUNER LAKE DAM (MO 30190). WHITE R--ETC(U)
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WHITE RIVER BASIN

NUWER LAKE DAM
OREGON COUNTY, MISSOURI
MO 65190

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

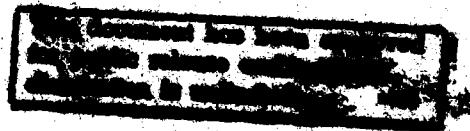


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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI



AUGUST, 1980

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| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property. | | | |



REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

SUBJECT: Nuwer Lake Dam Phase I Inspection Report

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This report presents the results of field inspection and evaluation of Nuwer Lake Dam (MO 30190).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as uns fe, non-emergency by the St. Louis District as a result of the application of the following criteria:

- a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.
- b. Overtopping of the dam could result in failure of the dam.
- c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY:

SIGNED
Chief, Engineering Division

11 SEP 1980

Date

APPROVED BY:

SIGNED
Colonel, CE District Engineer

11 SEP 1980

Date

WHITE RIVER BASIN

NUWER LAKE DAM

OREGON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30190

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared By

Anderson Engineering, Inc., Springfield, Missouri
Hanson Engineers, Inc., Springfield, Illinois

Under Direction Of

St. Louis District, Corps of Engineers

For

Governor of Missouri

August 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM
SUMMARY

| | |
|---------------------|--------------------------------------|
| Name of Dam: | Nuwer Lake Dam |
| State Located: | Missouri |
| County Located: | Oregon |
| Stream: | Unnamed Tributary of Frederick Creek |
| Date of Inspection: | June 18, 1980 |

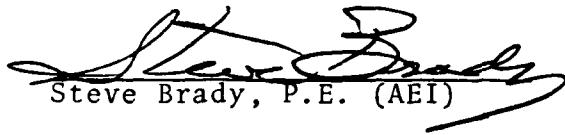
Nuwer Lake Dam was inspected by an interdisciplinary team of engineers from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers, and they have been developed with the help of several Federal and State agencies, professional engineering organizations, and private engineers. Based on these guidelines, the St. Louis District, Corps of Engineers has determined that this dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur if the dam fails. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are three buildings, two trailers, two sheds, two roads, and one dwelling. The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken. The dam is in the small size classification, since the maximum storage capacity is greater than 50 acre-ft but less than 1,000 acre-ft.

Our inspection and evaluation indicates that the combined spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The combined spillways will pass 22 percent of the Probable Maximum Flood (PMF) without overtopping. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The guidelines require that a dam of small size with a high downstream hazard potential pass 50 to 100 percent of the PMF. Considering the small height of the dam and the low reservoir storage capacity, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The 1 percent probability flood will not overtop the dam. The 1 percent probability flood is one that has a 1 percent chance of being exceeded in any given year.

Deficiencies visually observed by the inspection team were: (1) thick brier growth on the downstream embankment face; (2) apparent seepage areas on the downstream face between Stations 1+50 and 2+00 and at Station 2+84; and (3) lack of wave protection for the upstream face. Another deficiency was the lack of seepage and stability analysis records.

It is recommended that the owners take the necessary action without undue delay to correct the deficiencies reported herein. A detailed discussion of these deficiencies is included in the following report.



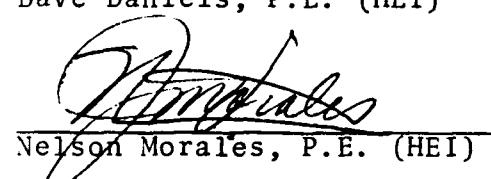
Steve Brady, P.E. (AEI)



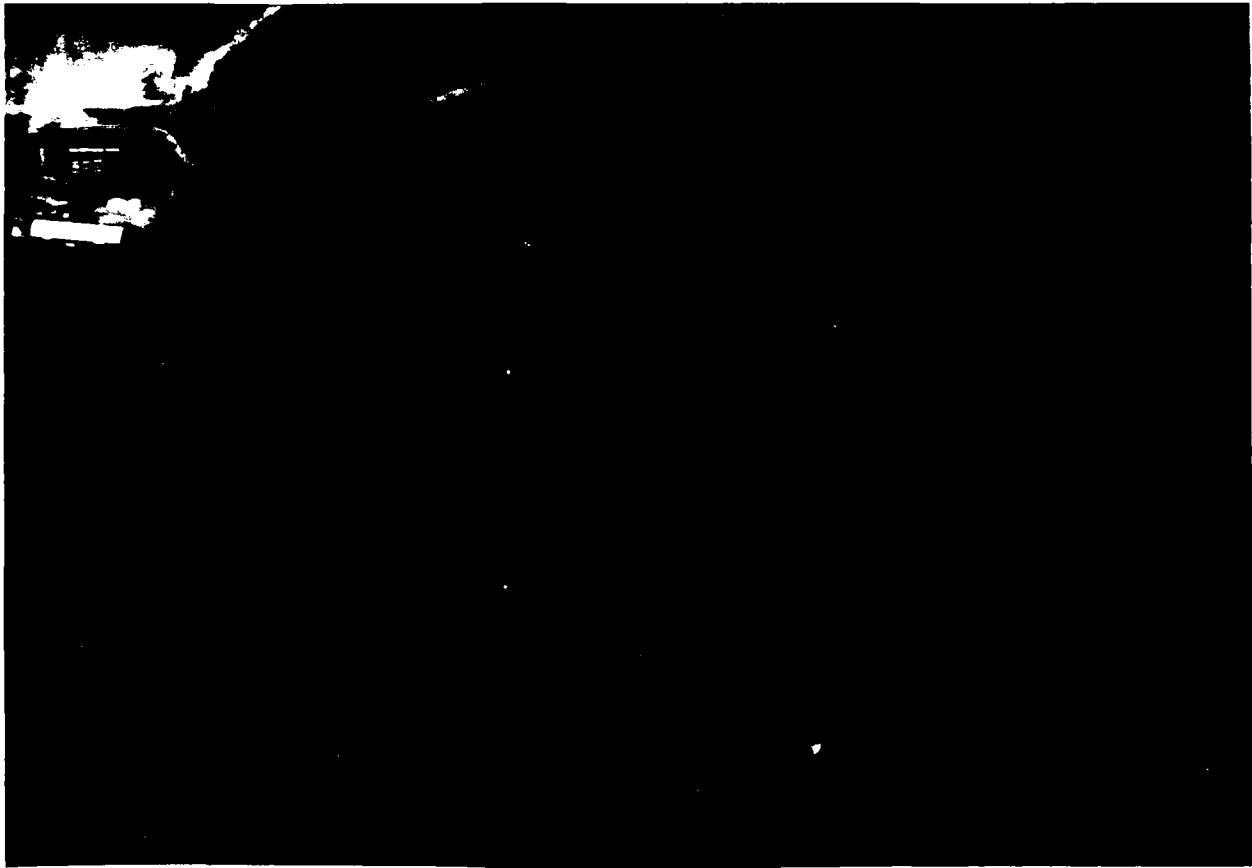
Tom Beckley
Tom Beckley, P.E. (AEI)



Dave Daniels
Dave Daniels, P.E. (HEI)



Nelson Morales
Nelson Morales, P.E. (HEI)



AERIAL VIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NUWER LAKE DAM - Id No. 30190

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

A. Authority:

The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection be made of Nuwer Lake Dam in Oregon County, Missouri.

B. Purpose of Inspection:

The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and a visual inspection in order to determine if the dam poses hazards to human life or property.

C. Evaluation Criteria:

Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, "Recommended Guidelines for Safety Inspection of Dams, Appendix D." These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT:

A. Description of Dam and Appurtenances:

Nuwer Lake Dam is an earth fill structure approximately 22 ft high and 540 ft long at the crest. In this report, right and left orientation is based on looking in the downstream direction. The appurtenant works consist of a 30 in. diameter drop inlet primary spillway and an 18 in. diameter outlet pipe connected to a 12 in. diameter drawdown pipe and slide gate. This intake structure is located near the center of the dam. A 2 in. diameter pipe passes through the dam next to the primary spillway pipe. This pipe has a wye connection on the downstream end with valves on both pipes which stem from the wye. One pipe empties into the plunge pool. The other pipe goes to a hog barn downstream of the dam. In addition, a trapezoidal earth cut emergency spillway is located at the left abutment. Sheet 5 of Appendix A shows a plan, profile, and typical section of the embankment. Presented on Sheet 6 of Appendix A are a profile and section of the emergency spillway.

B. Location:

The dam is located in the central part of Oregon County, Missouri, on an unnamed tributary of Frederick Creek. The dam and lake are within the Couch, Missouri, 15 minute quadrangle sheet (Section 2, T23N, R5W - latitude $36^{\circ}41.0'$; longitude $91^{\circ}28.7'$). Sheet 2 of Appendix A shows the general vicinity.

C. Size Classification:

With an embankment height of 22 ft and a maximum storage capacity of approximately 83 acre-ft, the dam is in the small size category.

D. Hazard Classification:

The St. Louis District, Corps of Engineers has classified this dam as a high hazard dam. The estimated damage zone extends approximately two miles downstream of the dam. Located within this zone are three buildings, two trailers, two sheds, two roads, and one dwelling. The existence of these downstream features was verified during the field inspection and at the time the aerial photographs were taken.

E. Ownership:

The dam is owned by Mr. Allen Nuwer. The owner's address is Route 3, Alton, Missouri 65606.

F. Purpose of Dam:

The dam was constructed primarily for recreation, livestock watering, and irrigation.

G. Design and Construction History:

The dam was designed by the Soil Conservation Service in 1969. Available design information includes calculations to size the spillways. These design data are included on the construction plans (Sheet 3, Appendix A).

The dam was constructed in 1969. The owner indicated that the dam was built according to the design plans. The embankment is comprised primarily of clayey materials obtained from the emergency spillway excavation, from the lake area, and from a knob upstream of the dam on the left side. The owner reported that a 10 ft deep key trench was incorporated into the dam. The base of the trench was in clay. In addition, select clayey material was used for a central embankment core. The embankment materials were placed with scrapers, and no sheepfoot compactor was used. The owner indicated that construction was observed by SCS personnel. However, it is

uncertain if any field tests were performed during construction. Anti-seep collars were provided around the spillway pipe.

The lake was drawn down sometime after the embankment was completed so that a riser pipe could be added to the 2 in. diameter pipe. This was done to provide better quality water for livestock and agricultural purposes.

H. Normal Operating Procedures:

Normal flows are discharged through an uncontrolled drop inlet spillway located near the center of the dam. The owner reported that the dam had never overtopped, and the emergency spillway located at the left abutment had never operated.

1.3 PERTINENT DATA:

Pertinent data about the dam, appurtenant works, and reservoir are presented in the following paragraphs. Sheet 5 of Appendix A presents a plan, profile, and typical section of the embankment, prepared from the site survey.

A. Drainage Area:

The drainage area for this dam, as obtained from SCS information is approximately 108 acres.

B. Discharge at Dam Site:

- (1) All discharge at the dam site is through uncontrolled spillways.
- (2) Estimated Total Spillway Capacity at Maximum Pool (Top of Dam - El. 912.5): 223 cfs
- (3) Estimated Capacity of Primary Spillway: 36 cfs
- (4) Estimated Experienced Maximum Flood at Dam Site: 26 cfs (Elev. 910.0)
- (5) Diversion Tunnel Low Pool Outlet at Pool Elevation: Not Applicable
- (6) Diversion Tunnel Outlet at Pool Elevation: Not Applicable
- (7) Gated Spillway Capacity at Pool Elevation: Not Applicable
- (8) Gated Spillway Capacity at Maximum Pool Elevation: Not Applicable

C. Elevations:

All elevations are consistent with an assumed mean sea level (MSL) elevation of 909.0 for the crest of the primary spillway (estimated from quadrangle map).

- (1) Top of Dam: 912.5
- (2) Primary Spillway Crest: 909.0
- (3) Emergency Spillway Crest: 910.7
- (4) Primary Spillway Pipe Invert at Outlet: 890.5
- (5) Streambed at Centerline of Dam: 892.0
- (6) Pool on Date of Inspection: 908.7
- (7) Apparent High Water Mark: 910.0
- (8) Maximum Tailwater: Unknown
- (9) Upstream Portal Invert Diversion Tunnel: Not Applicable
- (10) Downstream Portal Invert Diversion Tunnel: Not Applicable

D. Reservoir Lengths:

- (1) At Top of Dam: 800 ft
- (2) At Primary Spillway Crest: 700 ft
- (3) At Emergency Spillway Crest: 750 ft

E. Storage Capacities:

- (1) At Primary Spillway Crest: 56 acre-ft
- (2) At Top of Dam: 83 acre-ft
- (3) At Emergency Spillway Crest: 69 acre-ft

F. Reservoir Surface Areas:

- (1) At Primary Spillway Crest: 7.3 acres
- (2) At Top of Dam: 7.9 acres
- (3) At Emergency Spillway Crest: 7.6 acres

G. Dam:

- (1) Type: Earth
- (2) Length at Crest: 540 ft

- (3) Height: 22 ft
- (4) Top Width: 11 ft
- (5) Side Slopes: Upstream 2.3H:1.0V (from crest to water's edge); Downstream varies (see Sheet 5, Appendix A)
- (6) Zoning: None
- (7) Impervious Core: Center clay core of select material
- (8) Cutoff: Key trench 10 ft deep and 10 ft wide at base (from owner)
- (9) Grout Curtain: None

H. Diversion and Regulating Tunnel:

- (1) Type: Not Applicable
- (2) Length: Not Applicable
- (3) Closure: Not Applicable
- (4) Access: Not Applicable
- (5) Regulating Facilities: Not Applicable

I. Spillway:

I.1 Primary Spillway:

- (1) Location: Near Center of Dam
- (2) Type: Drop Inlet Steel Pipe (30" Drop Inlet, 18" Outlet Pipe)

I.2 Emergency Spillway:

- (1) Location: Left Abutment
- (2) Type: Trapezoidal Earth Cut

J. Regulating Outlets:

A 12 in. diameter steel pipe and slide gate are connected to the primary spillway intake structure. The slide gate is bolted in place to provide a positive seal to prevent leakage. To drain the lake, the bolts are removed and the gate is pulled up the inside of the riser tube from above.

The 2 in. diameter pipe through the dam is considered too small to effectively regulate the pool.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

An engineering geology report of the proposed lake site was prepared in 1968 by the Missouri Geological Survey. This report is included as Sheet 3, Appendix B.

The dam was designed in 1969 by the Soil Conservation Service. Available design information includes section and plan views of the dam and hydrologic and hydraulic calculations presented in Sheet 3, Appendix A.

A. Surveys:

A preliminary site survey was performed by SCS in 1969. A plan view of the area was prepared from this site survey and is presented on Sheet 4, Appendix A.

Sheet 5, Appendix A, presents a plan, profile and cross section of the dam from survey data obtained during the site inspection. The crest of the primary spillway (reservoir normal pool) was used as a reference point to determine all other elevations. It is estimated that this site datum approximately corresponds to mean sea level (MSL) elevation 909.0.

B. Geology and Subsurface Materials:

The site is located on the southern edge of the Ozarks' geologic region of Missouri. The Ozarks are characterized topographically by hills, plateaus and deep valleys. The most common bedrock types are dolomite, sandstone and chert. The "Geologic Map of Missouri" indicates that the bedrock in the site area consists primarily of the Jefferson City formation of the Canadian Series of the Ordovician System. The Jefferson City formation is composed principally of light brown to brown, medium to finely crystalline dolomite and argillaceous dolomite. The average thickness of the Jefferson City is 200 ft. An engineering geology report was prepared for this site by the Missouri Geological Survey in 1968 (see Sheet 3, Appendix B). This report states that the site "appears to have excellent possibilities for the construction and success of a small water retention structure."

The publication, "Caves of Missouri," indicates that nine caves are known to exist in Oregon County, only one of which is within ten miles of the site. That cave is located approximately four miles northwest of the dam.

The soils in the area of the dam are of the Clarksville-Fullerton-Talbott soil association. These soils have developed from cherty limestone and dolomite. The thickness of loessial deposits in upland areas is less than 2.5 ft.

Information from the Soil Conservation Service indicates that surface soils in the area are Elsah and Doniphan series. The Elsah series consists of well-drained soils developed in recent alluvium washed from uplands underlain by cherty dolomite and sandstone. The Doniphan series consists of upland soils formed in material weathered from cherty dolomite.

C. Foundation and Embankment Design:

The foundation and embankment design was performed by the Soil Conservation Service. The plans for construction (see Sheet 3, Appendix A) indicate a 10 ft wide key trench beneath the dam. In addition, an impervious core is indicated. The owner reported that the key trench was excavated about 10 ft deep, and that select clayey material was used in the central portion of the embankment section. The base of the key trench was in clay.

Upstream and downstream embankment slopes are shown on the plans as 3H:1V and 2H:1V, respectively. Survey data obtained during the site inspection indicate that the upstream embankment slope is about 2.3H:1.0V from the crest to the water surface, and the downstream slope varies from 1.9H:1.0V to 2.4H:1.0V.

D. Hydrology and Hydraulics:

Sheet 3, Appendix A contains some hydraulic and hydrology data developed by the Soil Conservation Service for this dam. Based on these data and a field check of spillway dimensions and embankment elevations, hydrologic analyses using U.S. Army Corps of Engineers' guidelines were performed and appear in Appendix C, Sheets 1 to 9.

E. Structure:

There are no structural design data available for this dam.

2.2 CONSTRUCTION:

The owner reported that a Soil Conservation Service representative was present during construction of the dam. However, it is not known if any field testing was performed, and no construction inspection data were available.

2.3 OPERATION:

Normal flows are passed by an uncontrolled drop inlet primary spillway and an earth cut emergency spillway. A 12 in. diameter steel dewatering pipe and slide gate are connected to the primary spillway inlet structure. In addition, a 2 in. diameter steel pipe passes through the dam next to the spillway pipe. This pipe has a wye connection on the downstream end with valves on both pipes which stem from the wye. One pipe empties into the plunge pool. The other pipe goes to a hog barn downstream of the dam. The lake was drained, and a riser was placed on the upstream end of the 2 in. pipe to obtain better quality water. This was done sometime after the lake was initially filled.

2.4 EVALUATION:

A. Availability:

The engineering data available are as listed in Section 2.1.

B. Adequacy:

The engineering data available were inadequate to make a detailed assessment of the design, construction, and operation of this structure. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

C. Validity:

The available engineering design data are considered valid. No valid engineering data on the construction of the embankment are available.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

A. General:

The field inspection was made on June 18, 1980. The inspection team consisted of personnel from Anderson Engineering, Inc. of Springfield, Missouri, and Hanson Engineers, Inc. of Springfield, Illinois. The team members were:

Steve Brady - Anderson Engineering, Inc. (Civil Engineer)
Tom Beckley - Anderson Engineering, Inc. (Civil Engineer)
Dave Daniels - Hanson Engineers, Inc. (Geotechnical Engineer)
Gene Werstepny - Hanson Engineers, Inc. (Hydraulic Engineer)

Photographs of the dam, appurtenant structures, reservoir, and downstream features are presented in Appendix D.

B. Dam:

The dam embankment appears to be in good condition. The downstream embankment face is heavily overgrown with briars, making inspection very difficult. The owner reported that he is currently spraying the briars to kill them. Small seepage areas were noted about 11 ft below the crest of the dam between Stations 1+50 and 2+00 and at Station 2+84. These areas were damp and soft, but no noticeable flows were noted. It did not appear that soil particles had been transported from these areas. The owner reported that this condition has been present since completion of the dam.

The horizontal and vertical alignments of the crest appeared good, and no surface cracking or unusual movement was obvious. No wave erosion was noted, although no erosion protection is provided for the upstream embankment face. The embankment-abutment contacts were in good condition.

Shallow auger probes into the embankment indicated the dam to consist of reddish brown clayey silt to silty clay with chert fragments (ML-CL). Information from the owner indicates that material for construction of the dam was obtained from a knob upstream of the dam on the left side, from the emergency spillway excavation, and from the lake area. Sheet 7 of Appendix A presents a plan sketch of the dam showing observed features.

C. Appurtenant Structures:

C.1 Primary Spillway:

The primary spillway consists of a 30 in. diameter drop inlet pipe and an 18 in. diameter outlet pipe. A wood plank anti-vortex wall and wire mesh trash rack fence are also provided.

The approach to the primary spillway is clear (see Photo 10). The spillway pipe appeared to be in good condition. The spillway outlets into a plunge pool which is lined with riprap at the toe of the dam (see Photo 13).

C.2 Emergency Spillway:

The earth cut emergency spillway is located at the left abutment. The approach channel is clear, and the spillway section is grass-covered. The owner reported that the emergency spillway has never operated. Spillway flows would be directed well away from the embankment.

D. Reservoir:

The watershed is generally wooded, with some agricultural activity on the left side of the lake. The slopes adjacent to the reservoir are moderate, and no sloughing or serious erosion was noted. No significant sedimentation was observed.

E. Downstream Channel:

The downstream channel is clear below the plunge pool before entering a wooded area approximately 150 ft downstream of the dam (see Photos 14 and 15).

3.2 EVALUATION:

The heavy growth of briars on the downstream embankment face can provide shelter for small burrowing animals. The seepage areas on the downstream face could adversely affect the stability of the dam. The owner is currently spraying a herbicide on the briars.

Because the 2 in. diameter pipe valves are located on the downstream side of the dam, the full head of water impounded by the dam is acting entirely through the dam. The area around the drain outlet should be periodically inspected for seepage which might indicate a leak or rupture of the pipe and could eventually initiate a piping failure through the embankment. The owner indicated that the 2 in. pipe is beside the 18 in. diameter spillway pipe and goes through the antiseep collars for the 18 in. pipe.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES:

The pool is normally controlled by rainfall, runoff, evaporation, the capacity of the uncontrolled spillways, and seepage from the reservoir. The 2 in. diameter pipe is opened periodically to water livestock and irrigate the owner's garden.

A 12 in. diameter drawdown pipe and bolted slide gate are incorporated into the spillway intake structure (see Photo 12). In order to effectively dewater the lake, the bolts sealing the slide gate are removed, and the gate is lifted manually with a chain from above.

4.2 MAINTENANCE OF DAM:

With the exception of the heavy brier growth on the downstream embankment face, the dam appears to be well maintained. The owner is currently removing the briars.

4.3 MAINTENANCE OF OPERATING FACILITIES:

The slide gate is visible from above and appeared to be in good condition. It is unknown if a program of regular maintenance of operating facilities is followed by the owner.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT:

The inspection team is unaware of any existing warning system for this dam.

4.5 EVALUATION:

The briars on the downstream embankment face and lack of wave protection for the upstream face are deficiencies. Vegetation on the dam should be cut annually, and wave protection should be provided for the upstream face. A program of regular maintenance of the operating facilities should be established and followed.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES:

A. Design Data:

The available SCS hydrologic and hydraulic design data are contained in the plans for construction (Sheet 3, Appendix A).

B. Experience Data:

No recorded rainfall, runoff, discharge, or reservoir stage data were available for this lake and watershed. The owner indicated that the maximum depth of water over the primary spillway was about 1 ft. The emergency spillway has never operated.

C. Visual Observations:

The spillway approaches were clear, and the spillways were in very good condition. The downstream channel is clear for 150 ft beyond the toe and enters a wooded area.

D. Overtopping Potential:

The hydraulic and hydrologic analyses (using the U.S. Army Corps of Engineers guidelines and the HEC-1 computer program) were based on: (1) a field survey of spillway dimensions and embankment elevations; and (2) the design data contained on the construction plans.

Based on the hydrologic and hydraulic analysis presented in Appendix C, the combined spillways will pass 22 percent of the Probable Maximum Flood. The Probable Maximum Flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The recommended guidelines from the Department of the Army, Office of the Chief of Engineers, require that this structure (small size with high downstream hazard potential) pass 50 percent to 100 percent of the PMF, without overtopping. Considering the small height of the dam and the low storage capacity of the reservoir, 50 percent of the PMF has been determined to be the appropriate spillway design flood. The spillways will pass the 1 percent probability flood without overtopping the dam.

Application of the Probable Maximum Precipitation (PMP), minus losses, resulted in a flood hydrograph peak inflow of 2,631 cfs. For 50 percent of the PMP, the peak inflow was 1,315 cfs.

The routing of the PMF through the spillways and dam indicates that the dam will be overtopped by 1.8 ft at elevation 914.3. The duration of the overtopping will be 6.0 hours, and the maximum outflow will be 2,561 cfs. The maximum discharge capacity of the spillways is 223 cfs. The routing of 50 percent of the PMF indicates that the dam will be overtopped by 1.2 ft at elevation 913.7. The maximum outflow will be 1,116 cfs, and the duration of overtopping will be 1.8 hours. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

A. Visual Observations:

Observed features which could adversely affect the structural stability of this dam are discussed in Sections 3.1B and 3.2.

B. Design and Construction Data:

The only design data for this dam are contained on Sheets 3 and 4, Appendix A. No construction data were available. Seepage and stability analyses comparable to the requirements of the guidelines were not available, which constitutes a deficiency which should be rectified.

C. Operating Records:

No operating records have been obtained.

D. Post-Construction Changes:

The only post-construction change involved dewatering the lake and placing a riser on the 2 in. diameter steel pipe soon after the dam was completed.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in stability analyses performed for this dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

This Phase I inspection and evaluation should not be considered as being comprehensive since the scope of work contracted for is far less detailed than would be required for an in-depth evaluation of dams. Latent deficiencies, which might be detected by a totally comprehensive investigation, could exist.

A. Safety:

The embankment is generally in good condition. Several items were noted during the visual inspection which should be investigated further, corrected or controlled. These items are: (1) thick brier growth on the downstream embankment face; (2) apparent seepage areas on the downstream face between Stations 1+50 and 2+00 and at Station 2+84; and (3) lack of wave protection for the upstream slope.

Another deficiency was the lack of seepage and stability analysis records.

The dam will be overtopped by flows in excess of 22 percent of the Probable Maximum Flood. Overtopping of an earthen embankment could cause serious erosion and could possibly lead to failure of the structure.

B. Adequacy of Information:

The conclusions in this report were based on review of the information listed in Section 2.1, the performance history as related by the owner, and visual observation of external conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

C. Urgency:

The remedial measures recommended in paragraph 7.2 should be accomplished in the near future. If the deficiencies listed in paragraph A are not corrected, and if good maintenance is not provided, the embankment condition will deteriorate and possibly could become serious in the future. The item recommended in paragraph 7.2A should be pursued without undue delay.

D. Necessity for Additional Inspection:

Based on the result of the Phase I inspection, no additional detailed inspection is recommended.

E. Seismic Stability:

The structure is located in seismic zone 1. An earthquake of this magnitude would not generally be expected to cause severe structural damage to a well constructed earth dam of this size. However, it is recommended that the prescribed seismic loading for this zone be applied in any stability analyses performed for this dam.

7.2 REMEDIAL MEASURES:

The following remedial measures and maintenance procedures are recommended. All remedial measures should be performed under the guidance of a professional engineer experienced in the design and construction of dams.

A. Alternatives:

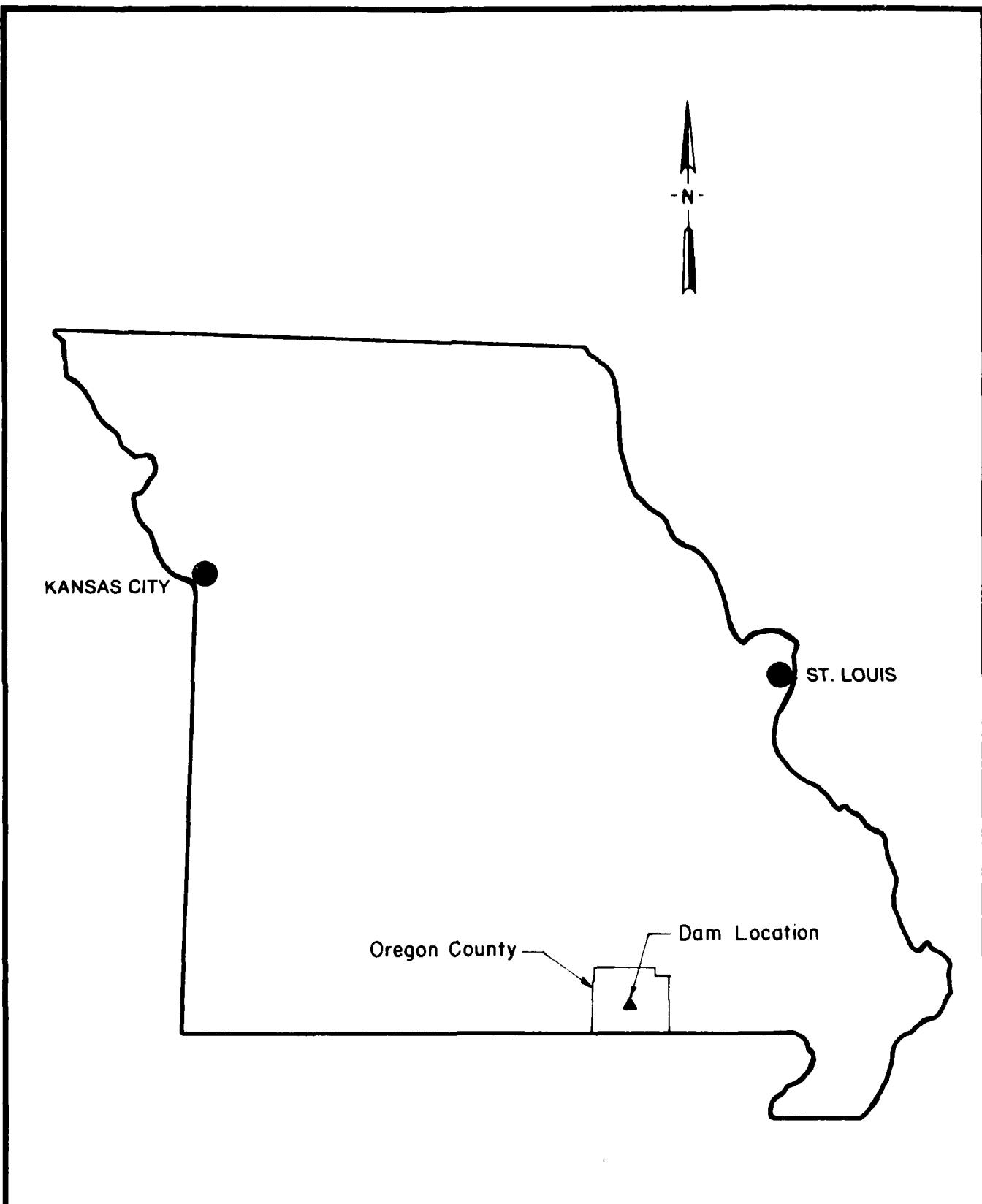
- (1) Spillway size and/or height of dam should be increased to pass 50 percent of the PMF. In either case, the emergency spillway should be protected to prevent erosion.

B. O&M Procedures:

- (1) Seepage and stability analyses comparable to the requirements of the recommended guidelines should be performed by an engineer experienced in the construction of dams.
- (2) The brier growth should be removed from the downstream face, and the vegetation on the dam should be cut annually.
- (3) The seepage areas previously described should be investigated by an engineer experienced in the design and construction of dams. Remedial measures may be required. As a minimum, these areas should be monitored to determine if there is any increase in flow quantities and whether soil particles are being carried with the seepage water.
- (4) Wave protection should be provided for the upstream face of the dam.
- (5) A detailed inspection of the dam should be made periodically by an engineer experienced in the design and construction of dams.

APPENDIX A

Dam Location and Plans



LOCATION MAP



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Nuwer Lake Dam
Oregon County, Missouri
Mo. I.D. No. 30190

SHEET 1, APPENDIX A



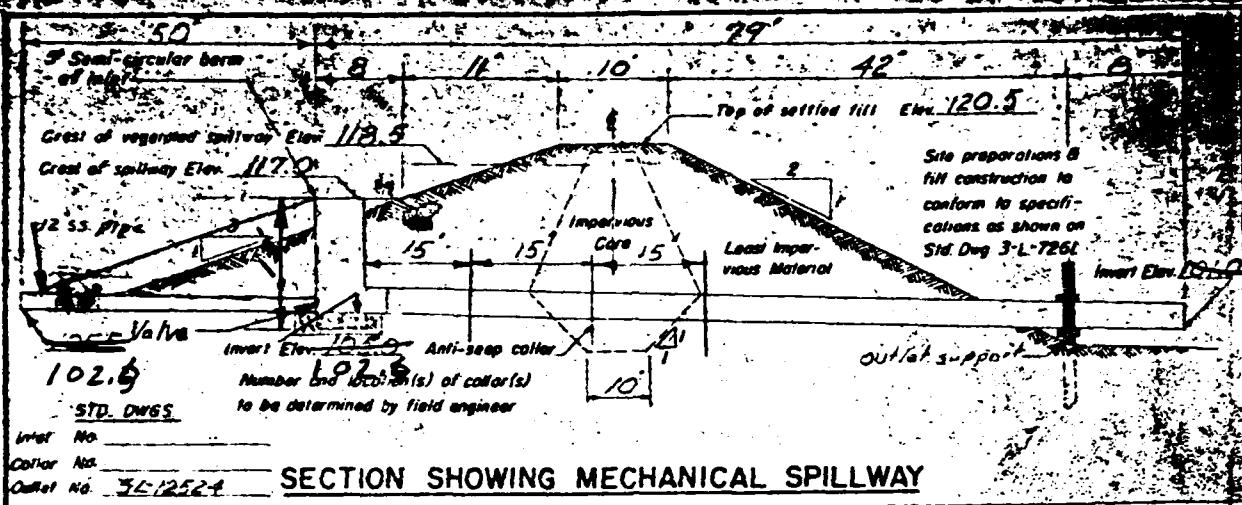
VICINITY MAP



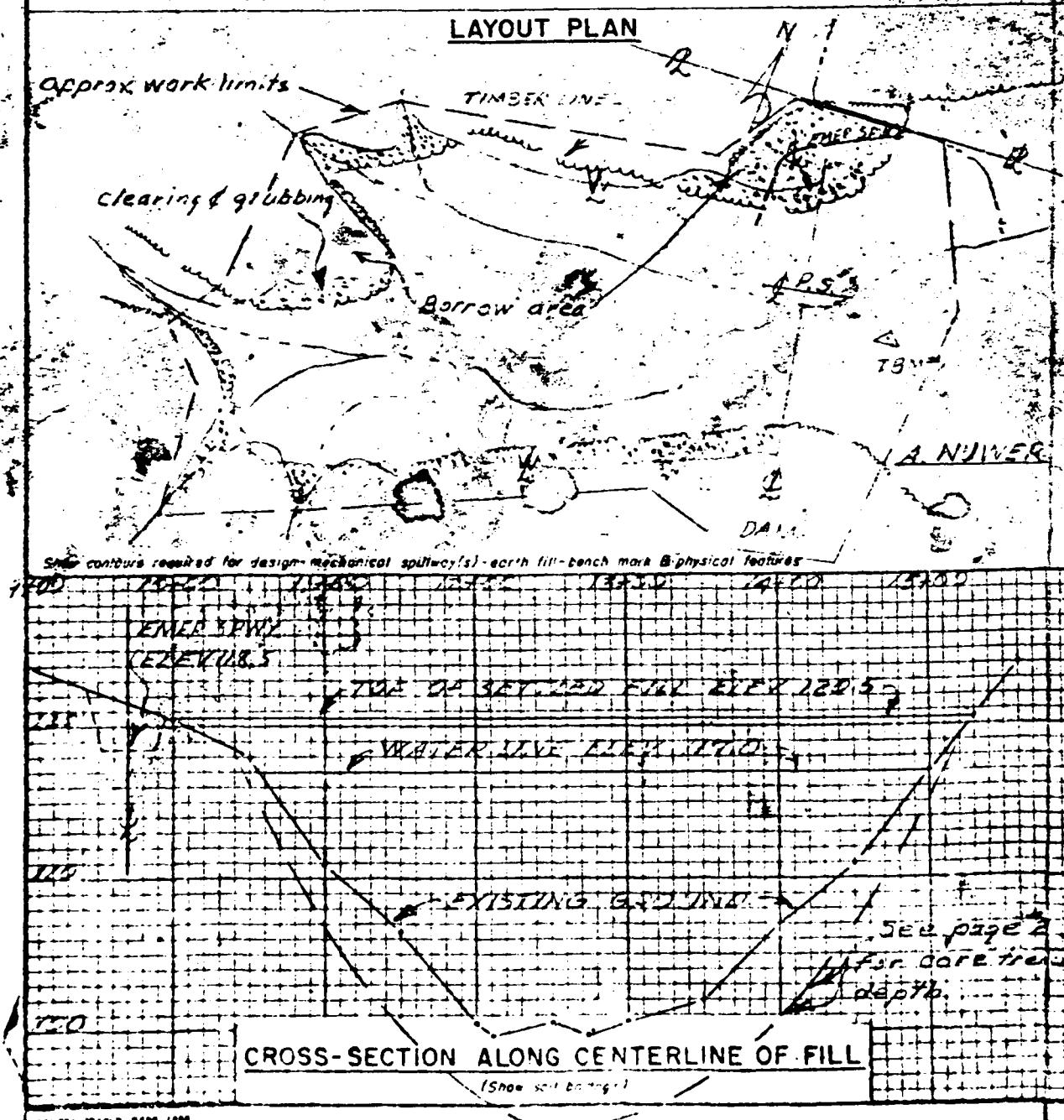
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Nuwer Lake Dam
Oregon County, Missouri
Mo. I.D. No. 30190

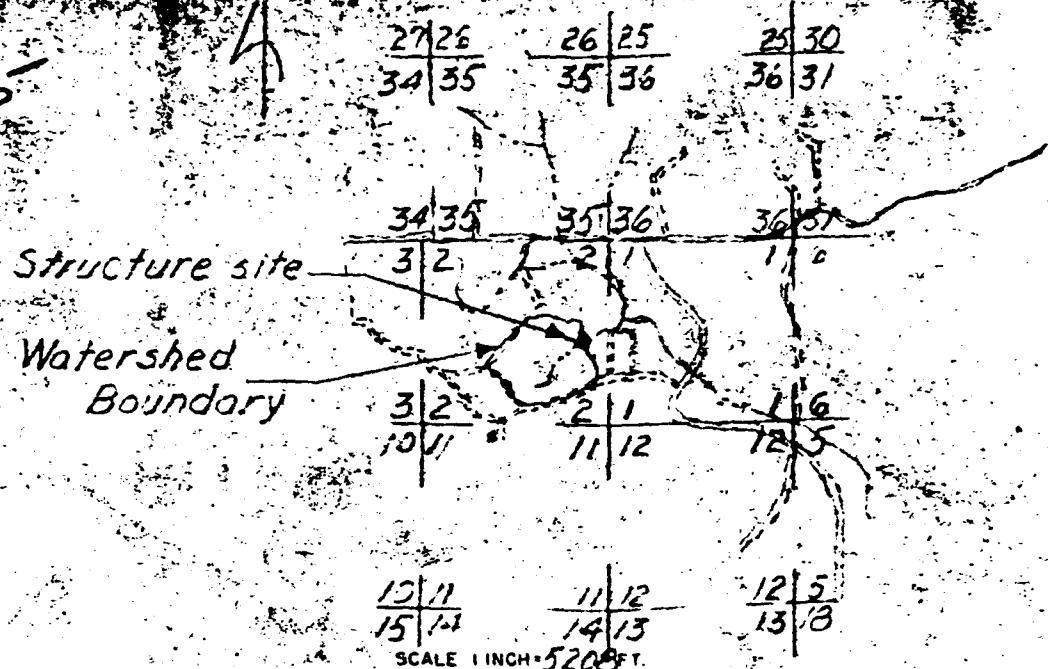
Sheet 2, Appendix A



SECTION SHOWING MECHANICAL SPILLWAY



WATERSHED MAP



DESIGN DATA

DRAINAGE AREA 1.08 ACS.
 SW (R) 15.1 H.S.S. (S)
 Q_d (P) 107 C.F.S.
 SURFACE AREA PERM. POOL 7.3 ACS.
 6 HOUR RAINFALL 3.95 IN. RUNOFF CURVE 75
 DESIGN RUNOFF 1.63 IN.

VOL FLOOD RUNOFF (V_f) 1.62 (R) 108 (DA) 14.0 AC. FT.

PIPE FLOW

Q_o-A 29H 18.02 H 32 C.F.S.
 It Ket KPL 1.04 1.04 1.04

H (TO EMER. SPILLWAY) 10.5 FT.

Q_o/Q_d K (FROM 3-L-45245)

MAXIMUM STAGE 1.5 FT.

VOL FLOOD STORAGE REQ'D (V_s) = K x V_r

$$1.2 \times 14.0 = 10.4 \text{ AC. FT.} \quad \frac{10.4}{54.5} = 0.19 \text{ FT.}$$

WEIR FLOW

WEIR SIZE L 14 FT. OR D 15 FT.

Q = 3.4 LH ^{3/2} OR (9.4 DH ^{3/2})

STAGE: INLET TO EMERG. SPILLWAY 1.5 FT.

25 yr = 20%

EMERGENCY SPILLWAY (Q = 275 LH ^{3/2})

DESIGN Q = 32 % OF 275 = 81.8 C.F.S.

WIDTH (L) = 36 FT DEPTH OF FLOW (H) = 1.0 FT.

FREEBOARD REQUIRED = 1.0 FT.

ESTIMATED QUANTITIES

| QUAN. | UNIT | ITEM |
|-------|------|--|
| 66 | FT | 10" SS PIPE |
| 10 | FT | 30" SS |
| 3 | EA | Act. Seep. 10" x 10" x 72" x 72" x 10" |
| 1 | EA | Ant.-Vortex 68" x 15" x 15" |
| 1 | EA | 20" x 10" SURFACE |
| 1 | EA | Trash rack |
| 5 | FT | 12" PIPE & VALVE |
| 20 | CY | CONCRETE - Take 1.75 CY |
| 15.8 | CY | EARTHFILL 12" x 12" x 12" = 10.58 CY |
| 1263 | CY | Core trench excavation |
| 1263 | CY | Soil trench backfill |

NOTE: Rivers in longitudinal seams of C.M. Pipe under watertight coupling band shall be flat head or omitted and seams welded inside and outside with a continuous 1/8" filler weld.

COOPERATOR A N U M E R

COOPERATING WITH ONEGA COUNTY SCD

STATE MINNESOTA SEC 2 T23 R5W

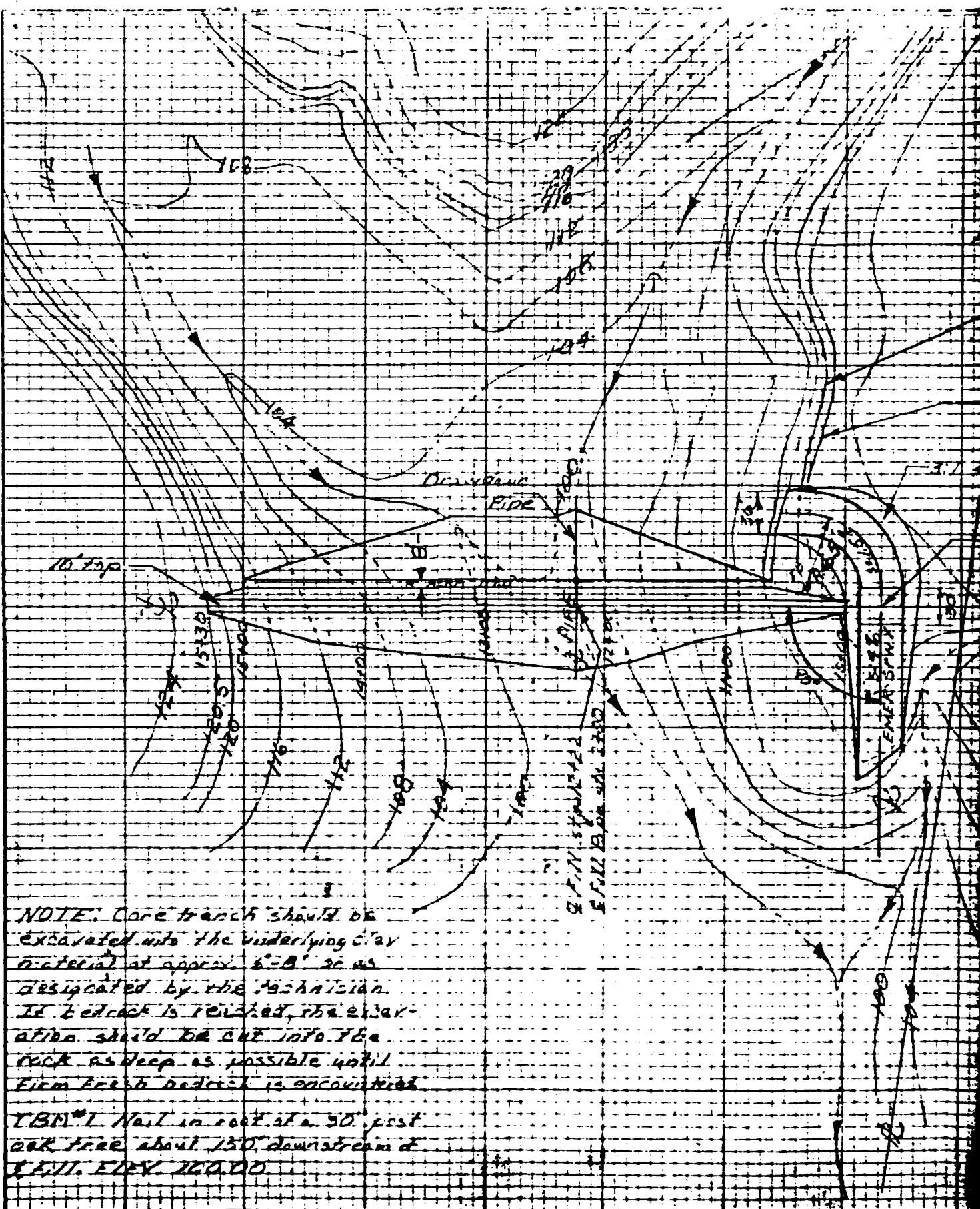
SURVEYED EDWARD SEES DATE 3-10-67

PIPE DROP INLET

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

| | | |
|--------|-------|-------|
| REAMES | 4-1/2 | 4-1/2 |
| REAMES | 6-6? | 6-6? |
| REAMES | 6-6? | 6-6? |
| ISCO | 6-6? | 6-6? |

SHEET 3, APPENDIX A



EP is located at 16.00 ft
37.10732 F.I.L.

Proposed Spillway sites & elev. 117.0

Emergency spill 10% rest elev. 119.5

3.1 side river

8 F.I.L. + 2 97.0

3 other sites 2 117.0
Central section 30 x 36'

NOTE At the most downstream site
the depth of water will be approx
6 ft and have approx. 2.2 Acre
feet.

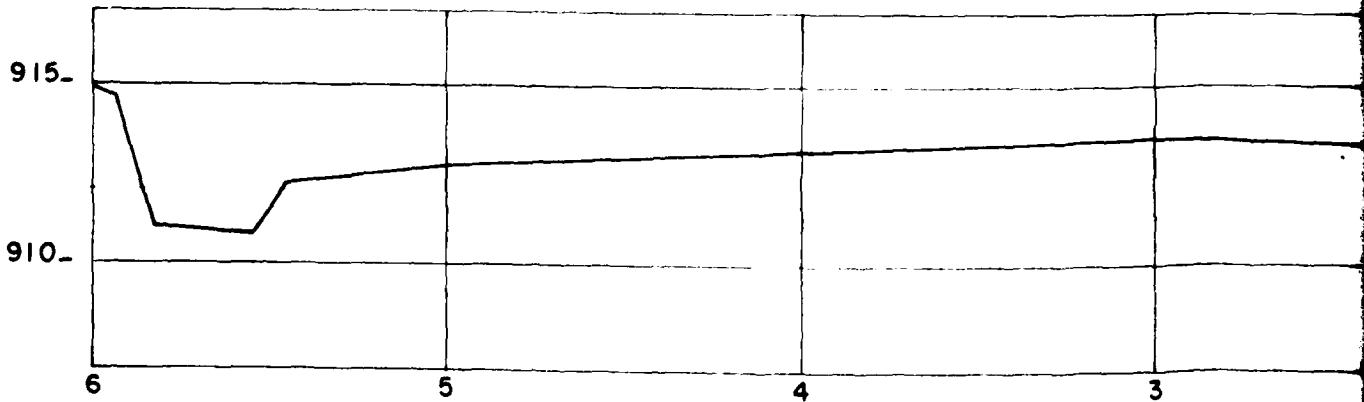
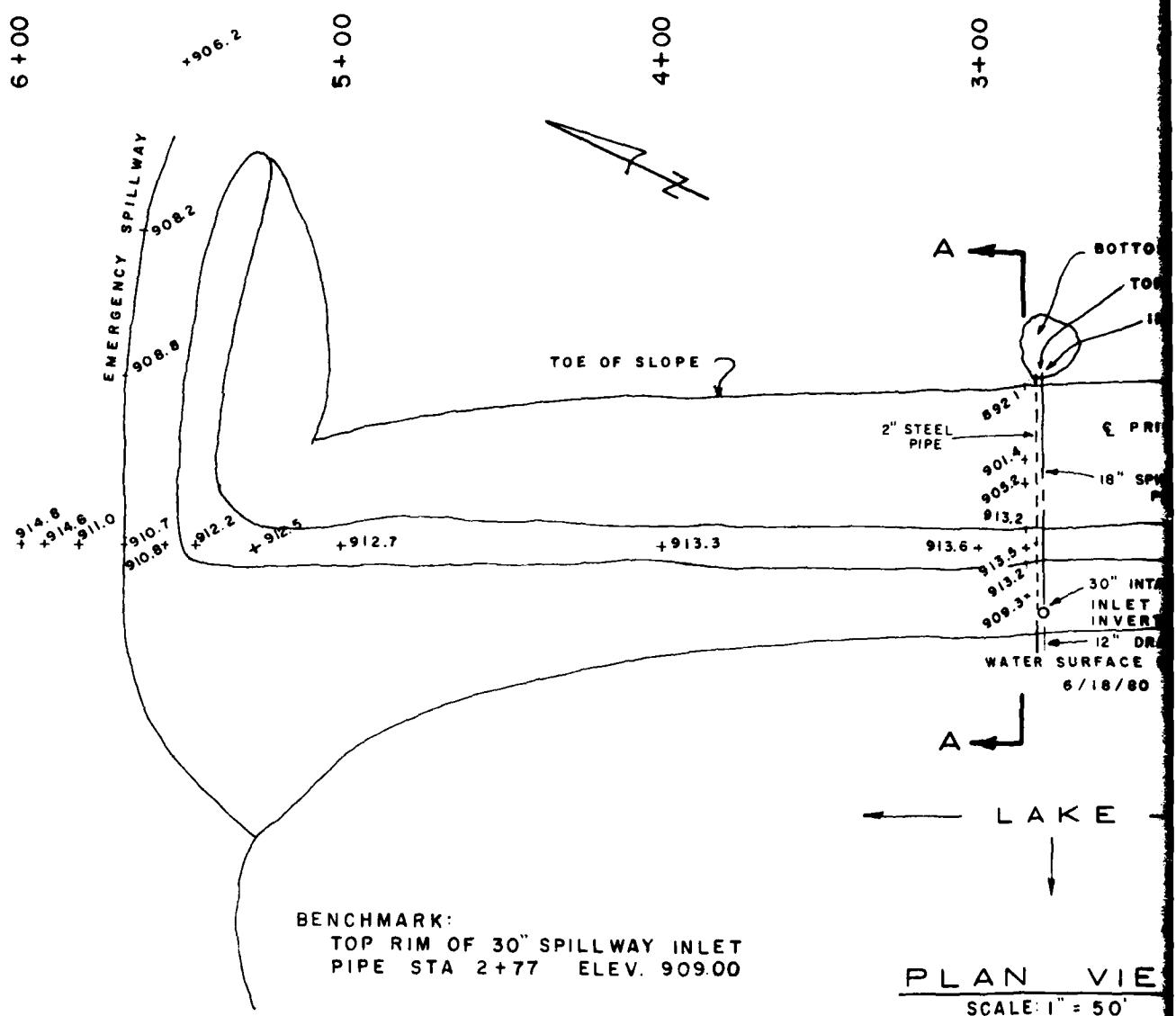
Site 1 117.0

COOPERATOR A NAME: DEC. 2 1968 S.H.
COOPERATING WITH: Oregon Soil and Water
COUNTY: Oregon STATE: Missouri
SURVEYED: L. G. REAMES DATE: 3-16-68

S. IN VIEW.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

| | |
|--------|-------------|
| Date | Approved by |
| 1000 | Title |
| REAMES | REAMES |
| 1000 | REAMES |
| 1000 | REAMES |
| 1000 | TSOR |



PROFILE

2+00

1+00

0+00

BOTTOM OF PLUNGE POOL ELEV. 884.5

TOP 2" PIPE ELEV. 891.2

INVERT 18" PIPE ELEV. 890.5

WATER SURFACE
ELEV. 908.7

909.3

PRIMARY SPILLWAY

18" SPILLWAY PIPE

913.2

912.8

+913.2

+913.1

913.5

+913.0

30" INTAKE RISER (PRIMARY SPILLWAY)

913.1

INLET ELEV. 909.0

INVERT ELEV. 894.6

12" DRAWDOWN PIPE

ELEV. 908.7

18/80

E →

VIEW

50'

20

- 915

- 910

Elev. (ft, MSL)

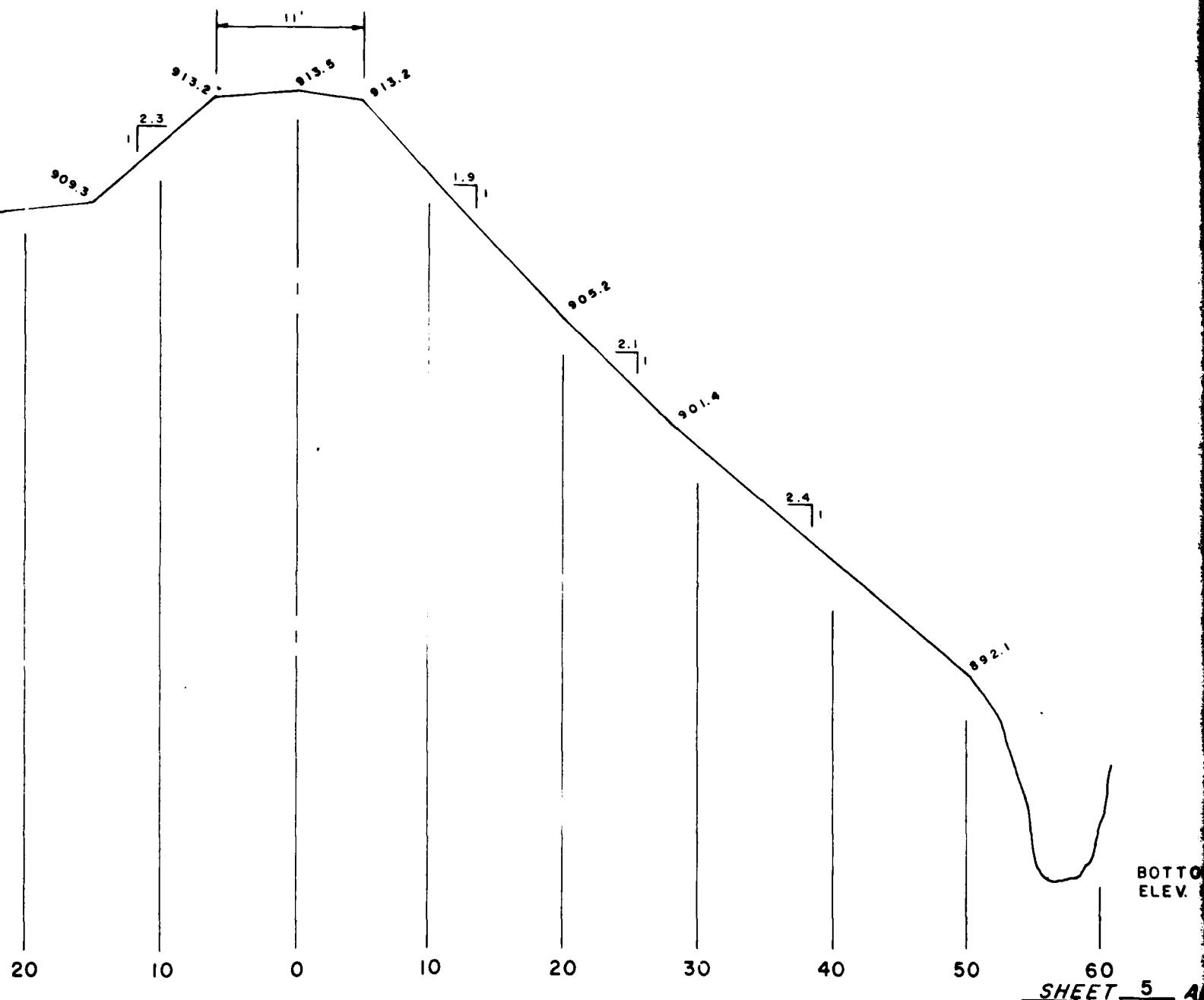
2

1

0

'25

L E



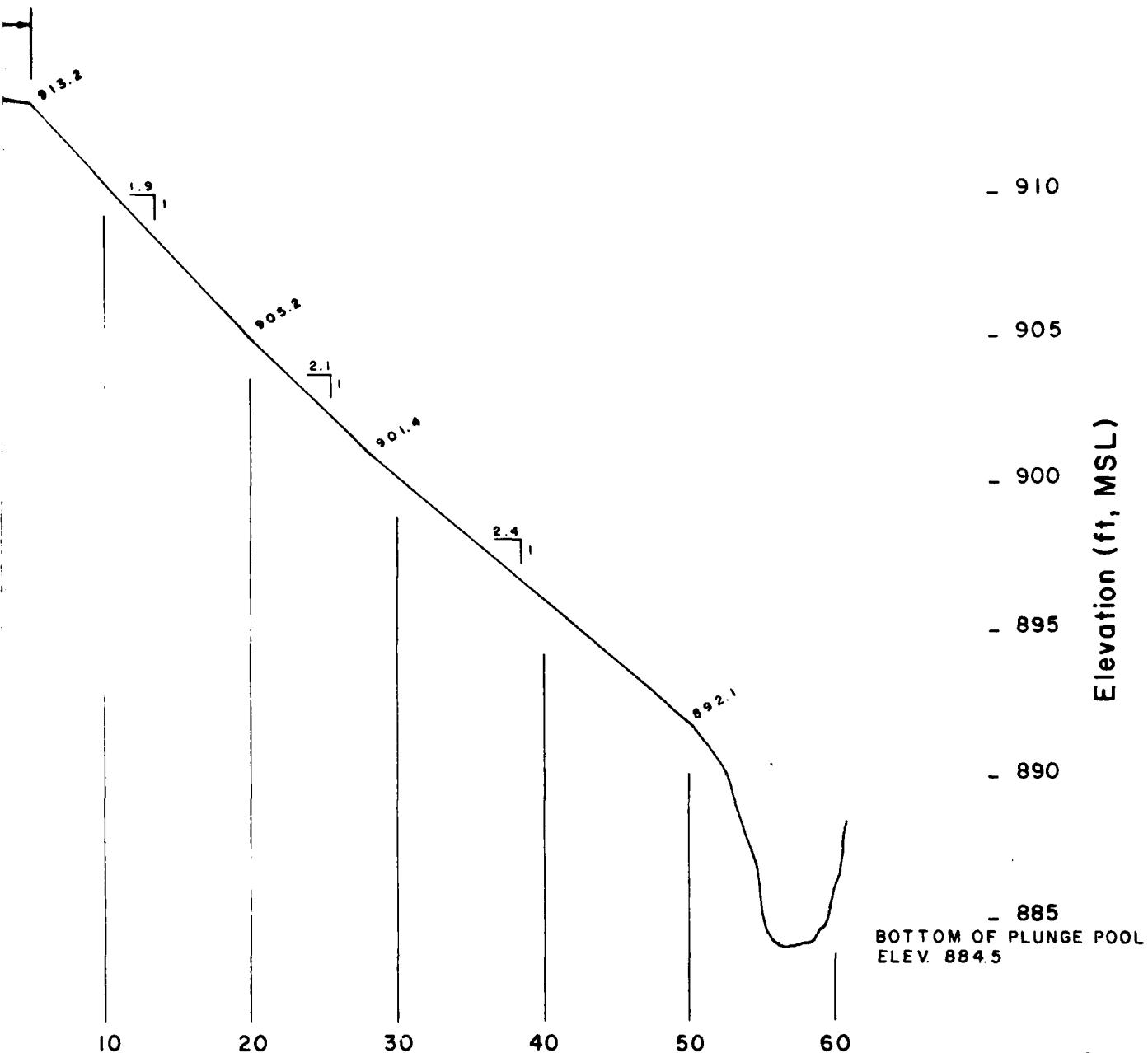
SECTION A-A STA 2+84

SHEET 5 A
ANDERSON ENG
730 NORTH BE
SPRINGFIELD,

NUWER
MO.

PLAN
OREGO

SECTION A-A STA 2+84



SHEET 5 APPENDIX A

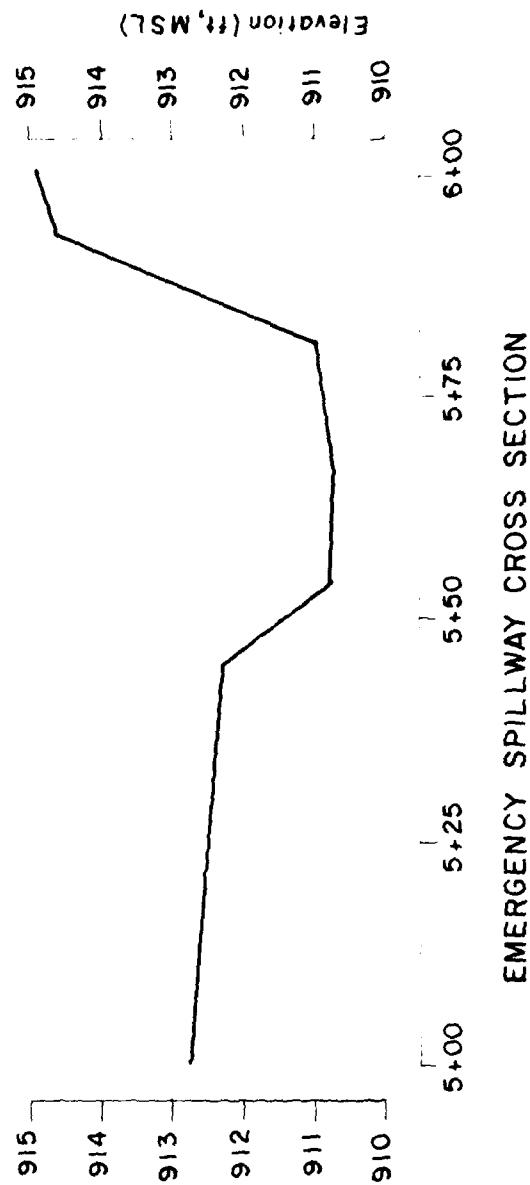
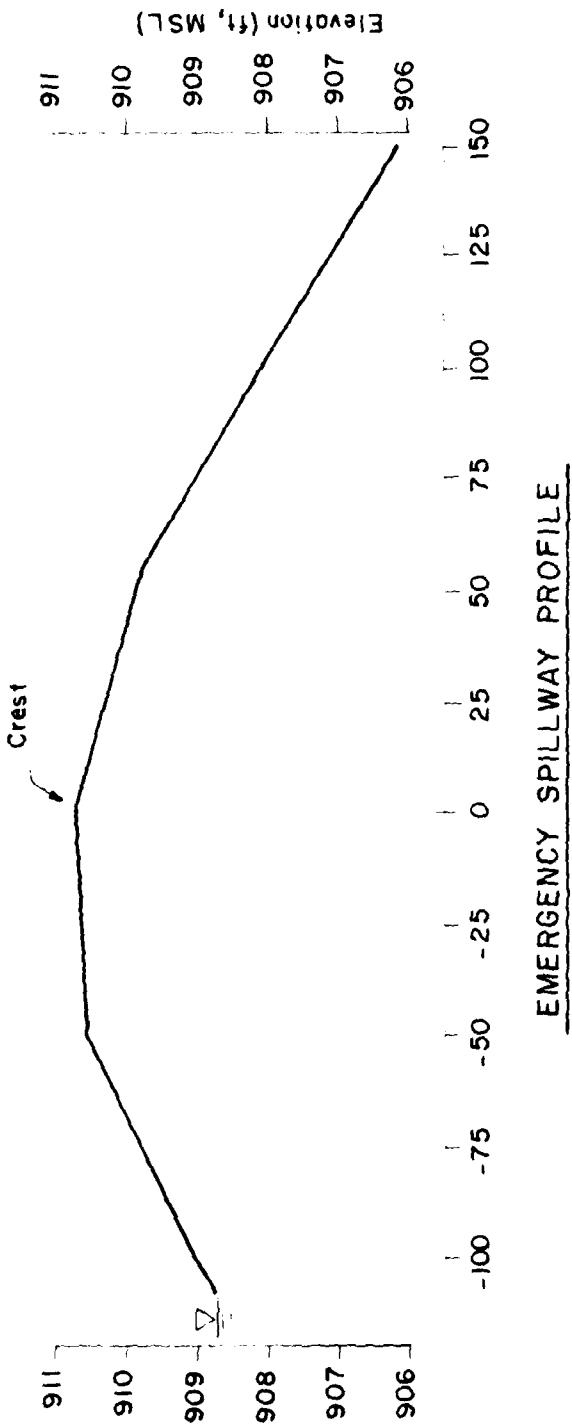
ANDERSON ENGINEERING, INC.
730 NORTH BENTON AVENUE
SPRINGFIELD, MISSOURI 65802

NUWER LAKE DAM

MO. No. 30190

PLAN & PROFILE

OREGON COUNTY, MO.



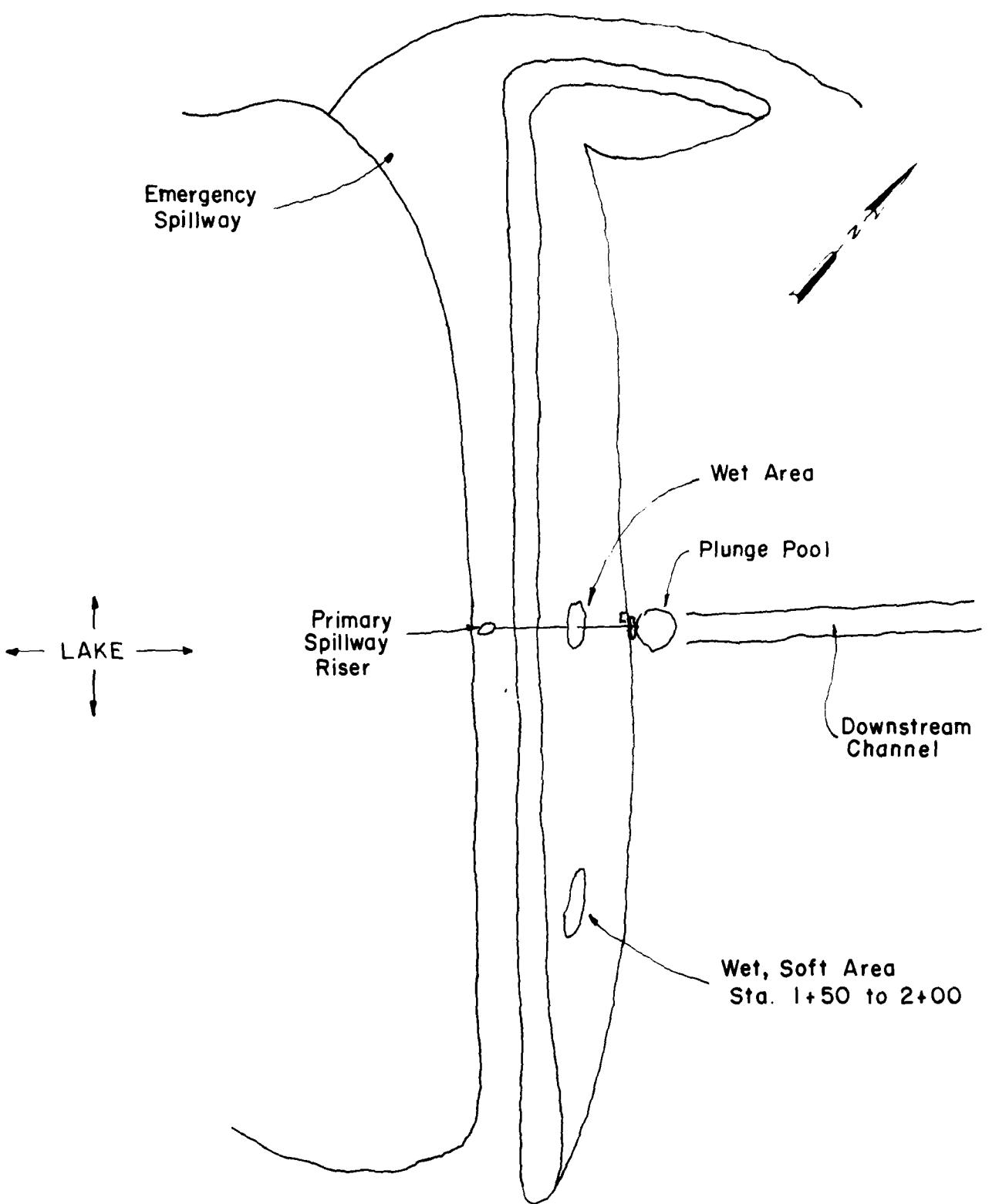
Profile & Section of Emergency Spillway



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Nuwer Lake Dam
Oregon County, Missouri
Mo. I.D. No. 30190

Sheet 6, Appendix A



PLAN SKETCH OF FEATURES



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

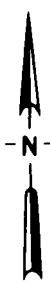
Nuwer Lake Dam
Oregon County, Missouri
Mo. I. D. No. 30190

Sheet 7, Appendix A

APPENDIX B

Geology and Soils

LEGEND



GLACIATED
PLAINS



WESTERN
PLAINS



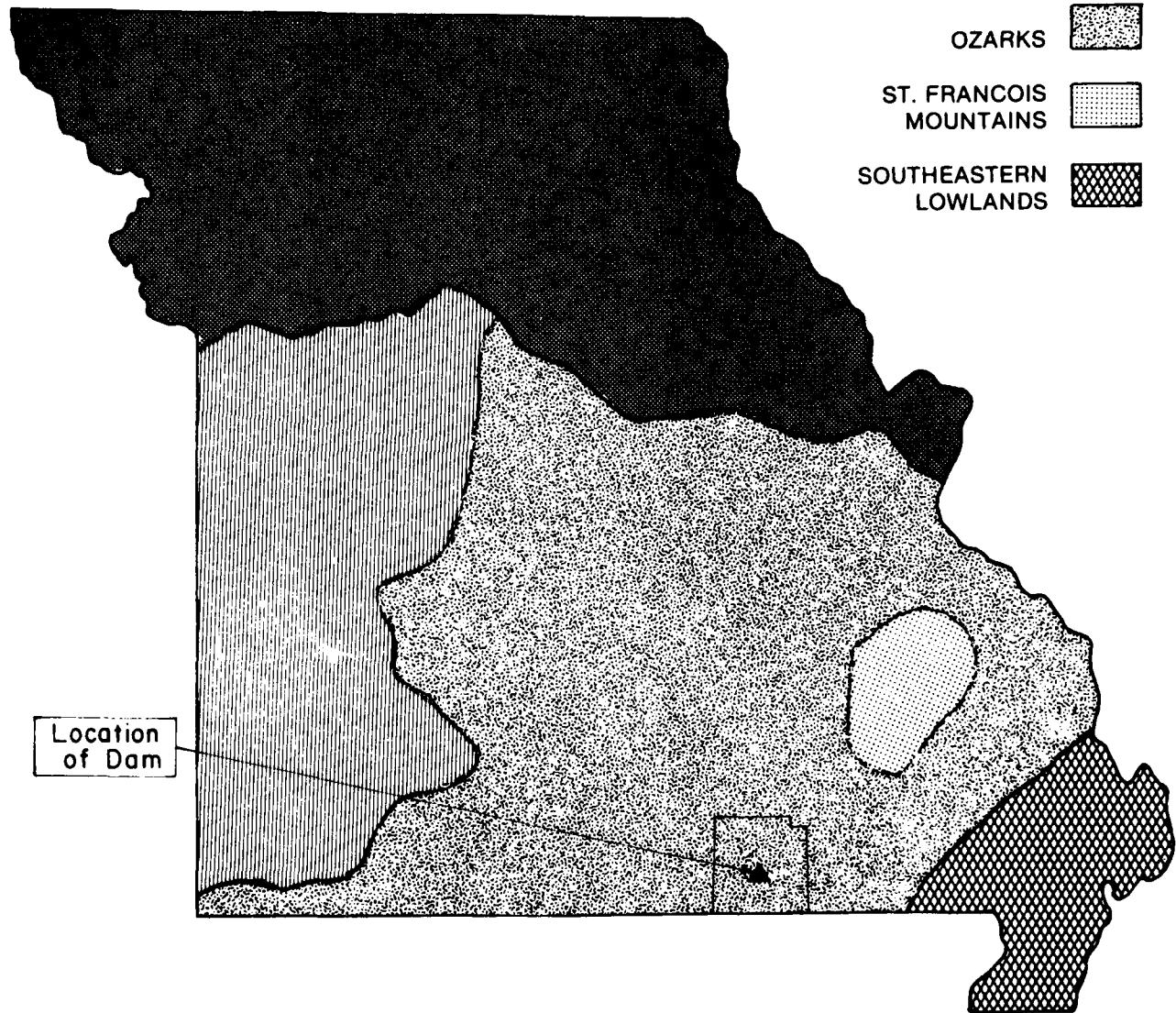
OZARKS



ST. FRANCOIS
MOUNTAINS



SOUTHEASTERN
LOWLANDS



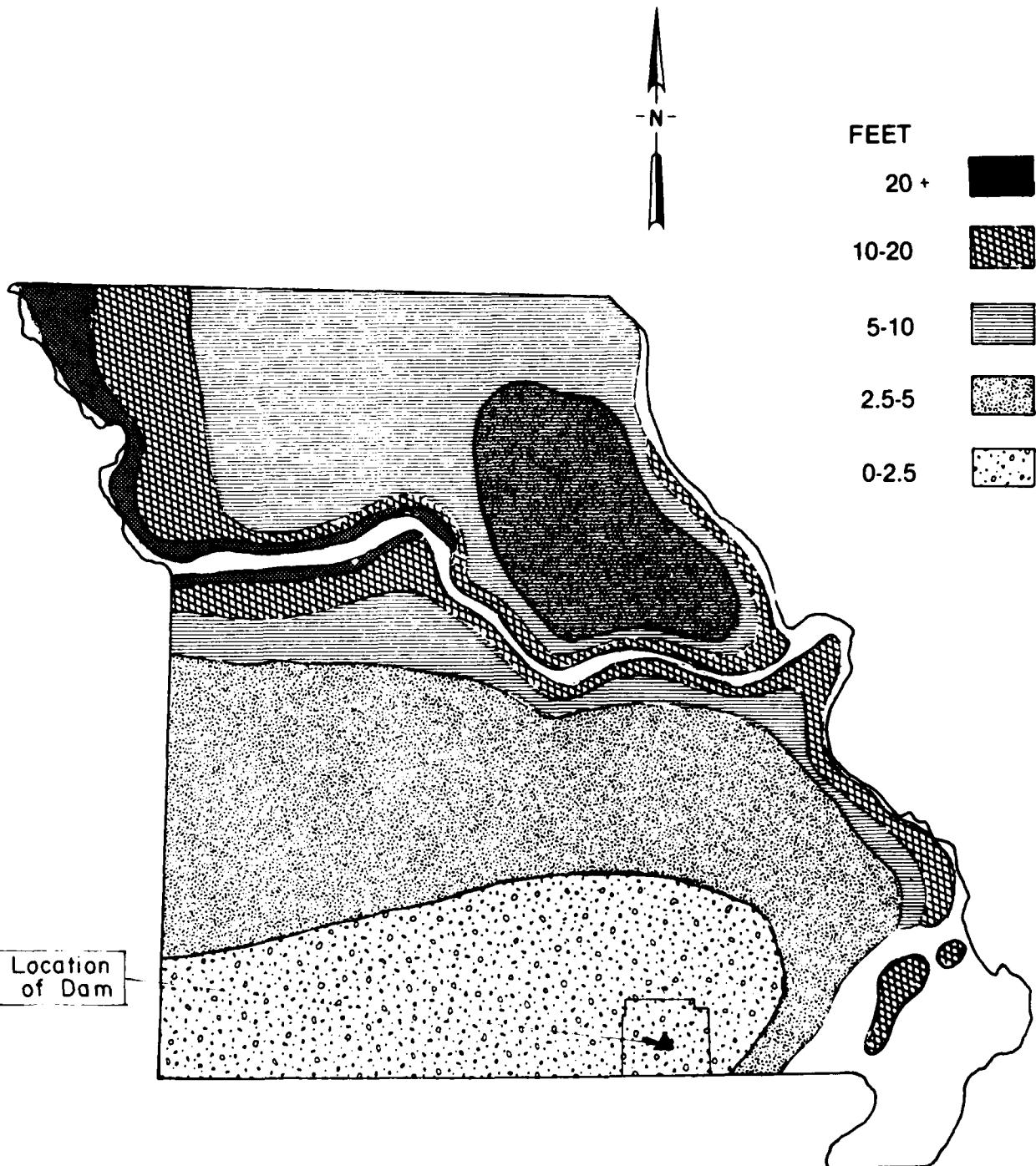
MAJOR GEOLOGIC REGIONS OF MISSOURI



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Nuwer Lake Dam
Oregon County, Missouri
Mo. I.D. No. 30190

SHEET 1, APPENDIX B



THICKNESS OF LOESSIAL DEPOSITS



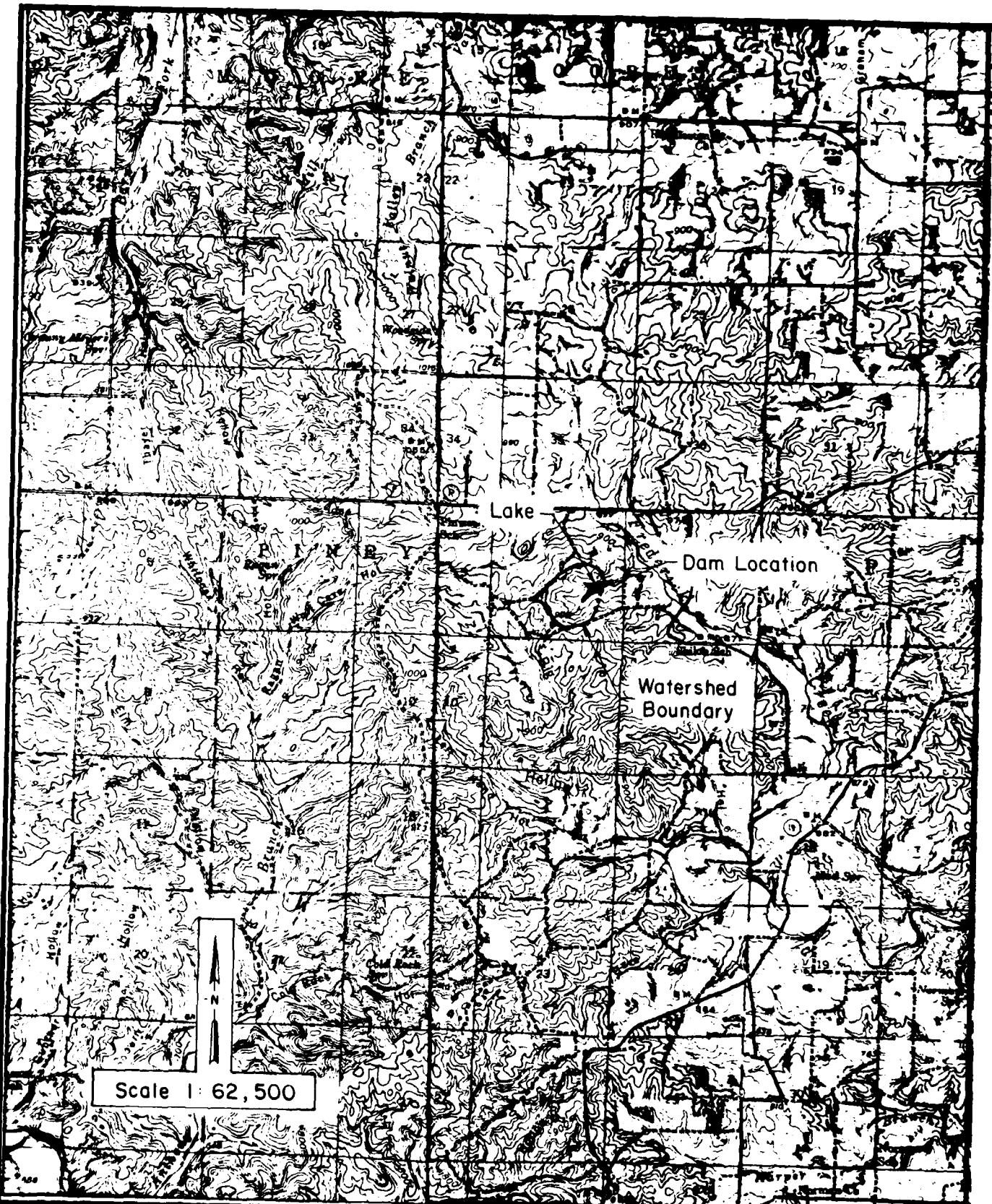
SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Nuwer Lake Dam
Oregon County, Missouri
Mo. I.D. No. 30190

SHEET 2, APPENDIX B

APPENDIX C

Overtopping Analysis



LAKE AND WATERSHED MAP



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Nuwer Lake Dam
Oregon County, Missouri
Mo. I.D. No. 30190

Sheet 1, Appendix C

APPENDIX C

HYDROLOGIC AND HYDRAULIC OVERTOPPING ANALYSIS

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was accomplished using the systemized computer program HEC-1 (dam Safety Version), July 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California.

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm duration was assumed according to the procedures outlined in EM 1110-2-1411 (SPD Determination). Also, the 1 percent chance probability flood was routed through the reservoir and spillway. Sullivan rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corps of Engineers, was used in this case.

The synthetic unit hydrograph for the watershed was developed by the computer program using the SCS method. The parameters for the unit hydrograph are shown in Table 1 (Sheet 3, Appendix C).

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationship. The CN values used, and the results from the computer output, are shown in Table 2 (Sheet 4, Appendix C).

The reservoir routing was accomplished by using the Modified Puls Method assuming the starting reservoir elevation at normal pool. The hydraulic capacity of the spillway was used as an outlet control in the routing. The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation-surface area--storage-discharge relationships shown in Table 3 (Sheet 4, Appendix C).

The rating curve for the spillway (see Table 4, Sheet 5, Appendix C) was determined assuming charts for corrugated metal pipe with entrance control and full flow control, from the U.S. Bureau of Public Roads.

The flow over the crest of the dam during overtopping was determined using the non-level dam option (\$L and \$V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5 (Sheet 6, Appendix C).

The computer input data, a summary of the output data, and a plot of the inflow-outflow hydrograph for the PMF are presented on Sheets 7, 8 and 9 of Appendix C.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

Parameters:

| | |
|-----------------------------|----------------|
| Drainage Area (A) | 0.17 sq. miles |
| Length of Watercourse (L) | 0.38 miles |
| Difference in elevation (H) | 96 feet |
| Time of concentration (Tc) | 0.15 hours |
| Lag Time (Lg) | 0.10 hours |
| Time to peak (Tp) | 0.14 hours |
| Peak Discharge (Qp) | 588 cfs |
| Duration (D) | 5 min. |

| <u>Time</u> (Min.) (*) | <u>Discharge</u> (cfs) (*) |
|------------------------|----------------------------|
| 0 | 0 |
| 5 | 372 |
| 10 | 551 |
| 15 | 242 |
| 20 | 94 |
| 25 | 36 |
| 30 | 14 |
| 35 | 6 |
| 40 | 2 |

(*) From the computer output

FORMULA USED:

$$T_c = \left(\frac{11.9 L}{H} \right)^3 0.385$$

From California Culverts Practice, California Highways and Public Works, September 1942.

$$Lg = 0.6 T_c$$

$$T_p = \frac{D}{2} + Lg$$

$$Q_p = \frac{484 A Q}{T_p} \quad Q = \text{Excess Runoff} = 1 \text{ inch}$$

TABLE 2

RAINFALL-RUNOFF VALUES

| <u>Selected Storm Event</u> | <u>Storm Duration (Hours)</u> | <u>Rainfall (Inches)</u> | <u>Runoff (Inches)</u> | <u>Loss (Inches)</u> |
|-----------------------------|-----------------------------------|------------------------------|----------------------------|--------------------------|
| PMP | 24 | 36.00 | 34.55 | 1.45 |
| 1% Prob. Flood | 24 | 7.55 | 4.87 | 2.68 |

Additional Data:

- 1) Soil Conservation Service Soil Group B
- 2) Soil Conservation Service Runoff Curve CN = 88 (AMC III) for the PMF
- 3) Soil Conservation Service Runoff Curve CN = 75 (AMC II) for the 1 percent probability flood
- 4) Percentage of Drainage Basin Impervious 8 percent

TABLE 3

ELEVATION, SURFACE AREA, STORAGE AND DISCHARGE RELATIONSHIPS

| <u>Elevation (feet-MSL)</u> | <u>Lake Surface Area (acres)</u> | <u>Lake Storage (acre-ft)</u> | <u>Spillway Discharge (cfs)</u> |
|---------------------------------|--|-----------------------------------|-------------------------------------|
| 892.0 | 0 | 0 | |
| 900.0 | 2.7 | 11 | |
| * 909.0 | 7.3 | 56 | 0 |
| 910.7 | 7.6 | 69 | 34 |
| ** 912.5 | 7.9 | 83 | 223 |
| 915.0 | 8.4 | 103 | 1018 |
| 920.0 | 9.3 | 147 | |

*Primary spillway crest elevation

**Top of dam elevation

The above relationships were developed using data from the SCS plans and the U.S.G.S. COUCH, MO. 15 minute quadrangle map (1944).

TABLE 4

SPILLWAYS RATING CURVE

| <u>Reservoir Elevation (ft, MSL)</u> | <u>Primary Spillway Discharge (cfs)</u> | <u>Emergency Spillway Discharge (cfs)</u> | <u>Total Discharge (cfs)</u> |
|--|---|---|--------------------------------------|
| 909.0 | 0 | | 0 |
| 909.5 | 9 | | 9 |
| 910.0 | 26 | | 26 |
| 910.7 | 34 | 0 | 34 |
| 911.2 | 35 | 21 | 56 |
| 911.7 | 35 | 69 | 104 |
| *912.5 | 36 | 187 | 223 |
| 912.7 | 36 | 227 | 263 |
| 913.5 | 37 | 430 | 467 |
| 914.5 | 38 | 780 | 818 |
| 915.5 | 39 | 1225 | 1264 |

* Top of dam elevation

METHOD USED:

a) Primary Spillway

$$Q = C.L.H^{1.5} \text{ for weir control condition}$$

$$Q = C_o.A. (2 g h)^{1/2} \text{ for orifice pipe entrance control condition}$$

Q = Discharge in c.f.s.

C = Weir discharge coefficient (varies 3.2 to 3.5)

L = Crest length in ft

H = Depth of water above the weir crest in ft

C_o = Orifice discharge coefficient = 0.60

A = Orifice area (outlet pipe area) in ft^2

g = Acceleration of gravity = 32.2 ft/sec²

h = Head measured from riser or reservoir elevation to center of orifice (in ft)

b) Emergency Spillway: Assuming open channel flow

Using charts from "UD Method of Reservoir Flood Routing," S.C.S.
Technical Release No. 35, February 1967.

TABLE 5
RESULTS OF FLOOD ROUTINGS

| Ratio of PMF | Peak Inflow (CFS) | Peak Lake Elevation (ft.-MSL) | Total Storage (AC.-FT.) | Peak Outflow (CFS) | Depth (ft.) Over Top of Dam |
|--------------------|-------------------------|-------------------------------------|-------------------------------|--------------------------|--------------------------------------|
| | 0 | * | 56 | 0 | |
| 0.10 | 263 | 910.9 | 71 | 44 | |
| 0.20 | 526 | 912.4 | 82 | 200 | |
| 0.22 | 579 | ** 912.5 | 83 | 223 | 0 |
| 0.25 | 658 | 912.8 | 85 | 303 | 0.3 |
| 0.30 | 789 | 913.1 | 88 | 437 | 0.6 |
| 0.35 | 921 | 913.3 | 90 | 600 | 0.8 |
| 0.40 | 1052 | 913.5 | 91 | 803 | 1.0 |
| 0.50 | 1315 | 913.7 | 92 | 1116 | 1.2 |
| 0.75 | 1973 | 914.0 | 95 | 1882 | 1.5 |
| 1.00 | 2631 | 914.3 | 97 | 2561 | 1.8 |

The percentage of the PMF that will reach the top of the dam is 22 percent.

*Primary spillway crest elevation

**Top of dam elevation

A OVERTOPPING ANALYSIS FOR NUNUER LAKE DAM (# 12)
 A STATE ID NO. 30190 COUNTY NAME : OREGON
 A HANSON ENGINEERS INC. DAM SAFETY INSPECTION JOB # 8053001

| | | | |
|----|-------|---|-------|
| | | 300 | 5 |
| B1 | 5 | J | 1 |
| J1 | .10 | J1 | .20 |
| K | 0 | K | 1 |
| K1 | | INFLOW HYDROGRAPH COMPUTATION ** | |
| N | 1 | 2 | 0.17 |
| P | 0 | 27.7 | 102 |
| T | | 120 | 130 |
| U2 | 0.15 | 0.10 | |
| X | 0 | -.1 | 2 |
| K | 1 | 2 | |
| K1 | | RESERVOIR ROUTING BY MODIFIED PULS AT DAM SITE ** | |
| Y | 1 | 1 | 1 |
| Y1 | 1 | | |
| Y4 | 909.0 | 909.5 | 910.0 |
| Y4 | 915.5 | 910.7 | 911.2 |
| Y5 | 0 | 26 | 34 |
| Y5 | 1264 | | |
| 95 | 0 | 11 | 56 |
| SE | 892.0 | 900.0 | 909.0 |
| SE | 909.0 | 910.7 | 912.5 |
| 99 | 912.5 | | |
| SL | 0 | 40 | 110 |
| SL | 912.5 | 912.7 | 913.1 |
| K | 99 | | |
| | | | 0.40 |
| | | | .35 |
| | | | .40 |
| | | | .3 |
| | | | .50 |
| | | | .75 |
| | | | 1.0 |
| | | | 1 |
| | | | 1 |
| | | | 1 |
| | | | -1 |
| | | | -88 |
| | | | 0.08 |

PMF RATIOS
INPUT DATA

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLows IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

| OPERATION | STATION | AREA | RATIOS APPLIED TO FLOWS | | | | | | RATIO 8 | RATIO 9 |
|---------------|---------|-----------------|-------------------------|------------------|------------------|------------------|------------------|------------------|-------------------|-------------------|
| | | | PLAN | RATIO 1 | RATIO 2 | RATIO 3 | RATIO 4 | RATIO 5 | | |
| | | | 0.10 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.50 | 0.75 |
| HYDROGRAPH AT | 1 | 0.17 (0.44) | 1 (7.45) | 263. (14.90) | 526. (18.62) | 658. (22.35) | 789. (26.07) | 921. (29.80) | 1052. (37.25) | 1315. (55.87) |
| ROUTED TO | 2 | 0.17 (0.44) | 1 (1.26) | 44. (5.68) | 200. (8.57) | 303. (12.38) | 437. (16.98) | 600. (22.73) | 803. (31.61) | 1116. (33.30) |

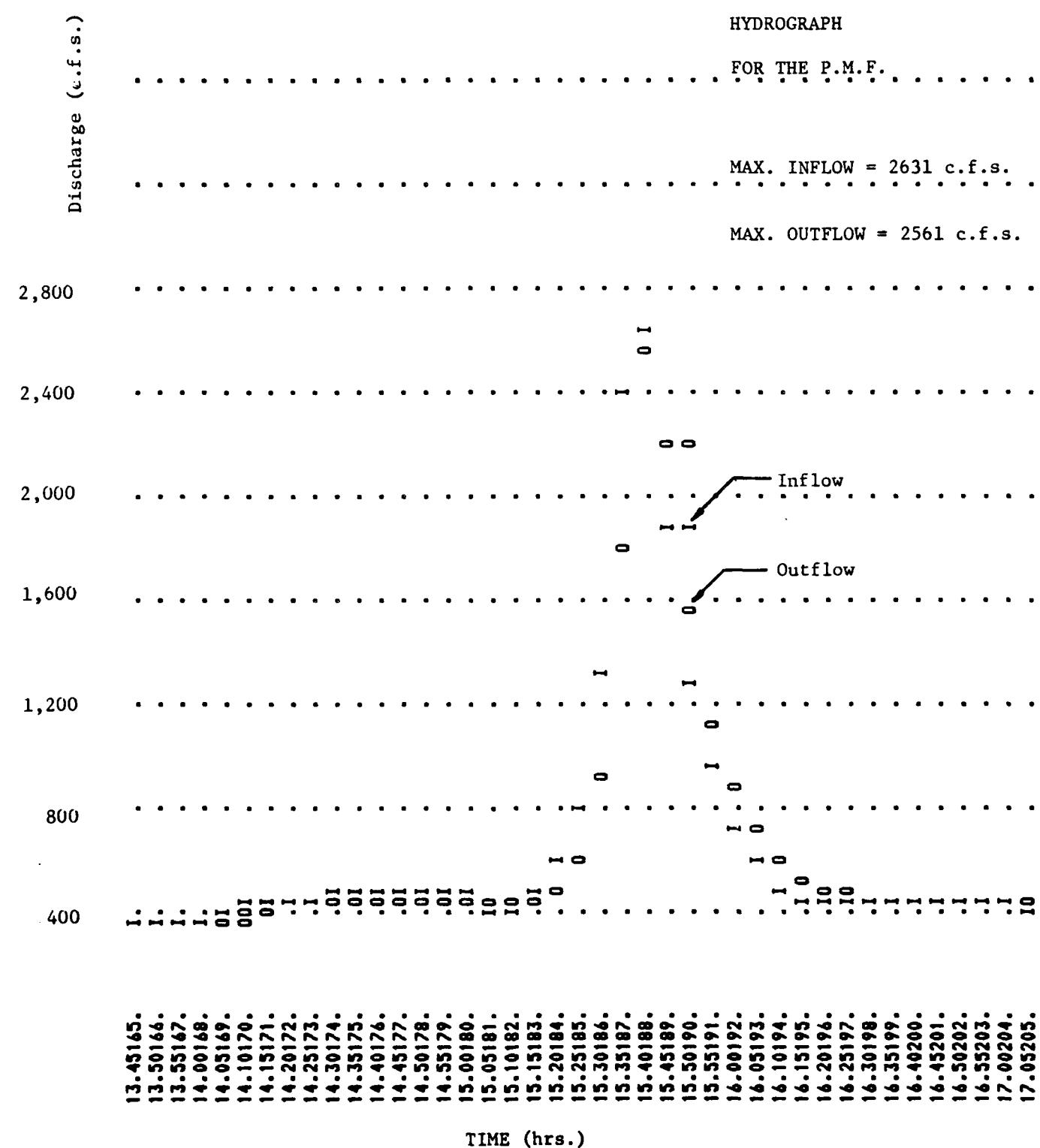
SUMMARY OF DAM SAFETY ANALYSIS

| INITIAL VALUE | SPILLWAY CREST | TOP OF DAM |
|---------------|----------------|------------|
| ELeVATION | 909.00 | 912.50 |
| STORAGE | 56. | 83. |
| OUTFLOW | 0. | 0. |

PLAN 1

| RATIO OF RESERVOIR W.S.ELEV | MAXIMUM DEPTH OVER DAM | MAXIMUM STORAGE AC-FT | MAXIMUM OUTFLOW CFS | DURATION | | TIME OF FAILURE | |
|--------------------------------------|------------------------------|-----------------------------|---------------------------|----------|-------|--------------------|-------|
| | | | | OVER TOP | HOURS | MAX QUITFLOW | HOURS |
| 0.10 | 910.94 | 0.00 | 71. | 44. | 0.00 | 16.33 | 0.00 |
| 0.20 | 912.35 | 0.00 | 82. | 200. | 0.00 | 15.92 | 0.00 |
| 0.25 | 912.81 | 0.31 | 85. | 303. | 0.50 | 15.83 | 0.00 |
| 0.30 | 913.12 | 0.62 | 88. | 437. | 0.75 | 15.83 | 0.00 |
| 0.35 | 913.33 | 0.83 | 90. | 600. | 0.92 | 15.75 | 0.00 |
| 0.40 | 913.50 | 1.00 | 91. | 803. | 1.08 | 15.75 | 0.00 |
| 0.50 | 913.68 | 1.18 | 92. | 1116. | 1.83 | 15.75 | 0.00 |
| 0.75 | 914.01 | 1.51 | 95. | 1882. | 4.75 | 15.67 | 0.00 |
| 1.00 | 914.26 | 1.76 | 97. | 2561. | 5.92 | 15.67 | 0.00 |

PMF RATIOS OUTPUT DATA

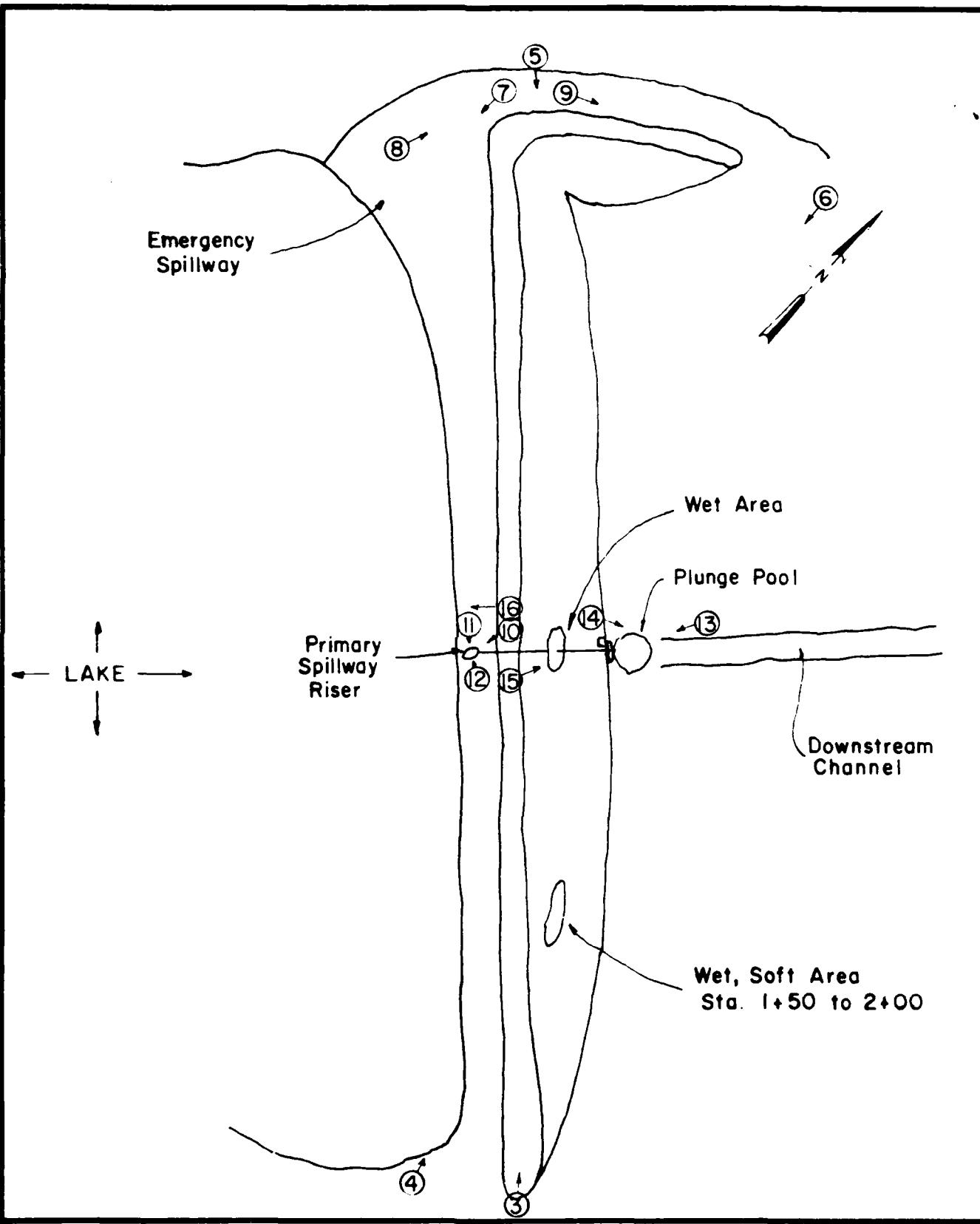


APPENDIX D

Photographs

LIST OF PHOTOGRAPHS

| <u>Photo No.</u> | <u>Description</u> |
|------------------|---|
| 1. | Aerial View of Lake and Dam |
| 2. | Aerial View of Dam |
| 3. | Crest of Dam - Looking From Right Abutment |
| 4. | Upstream Face of Dam - Looking From Right Abutment |
| 5. | Crest of Dam - Looking From Emergency Spillway |
| 6. | Downstream Face of Dam |
| 7. | Emergency Spillway Crest - Looking Upstream |
| 8. | Emergency Spillway Crest - Looking Downstream |
| 9. | Emergency Spillway Outlet Channel - Looking Downstream |
| 10. | Primary Spillway Inlet and Approach Area |
| 11. | Close-Up of Primary Spillway Inlet |
| 12. | View Down Primary Spillway Riser Pipe |
| 13. | Primary Spillway Outlet and Plunge Pool |
| 14. | View of Downstream Channel - Looking Downstream |
| 15. | View of Plunge Pool and Downstream Channel |
| 16. | View of Lake and Watershed Area (Note buoys marking location of 2 in. diameter riser pipe.) |



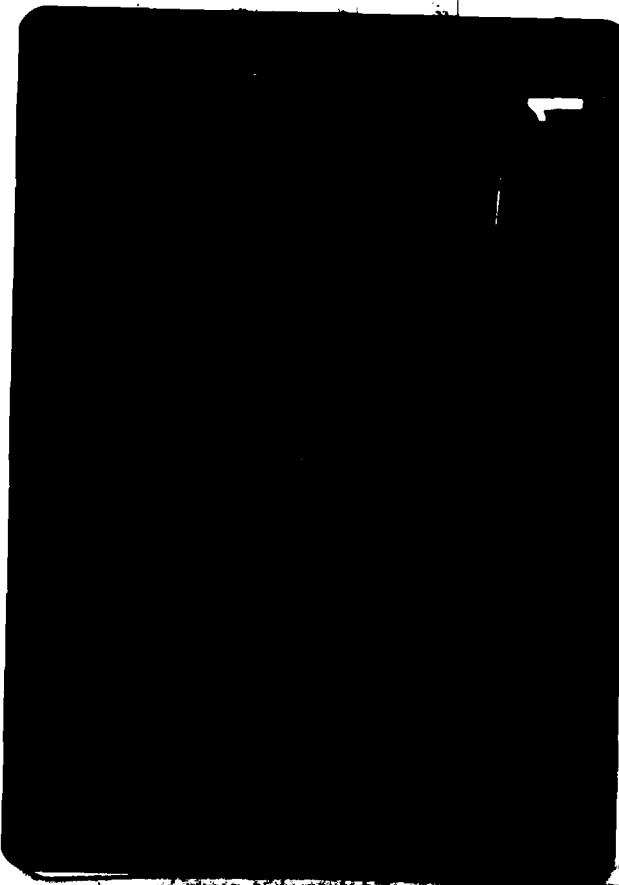
PHOTOGRAPH LOCATIONS



SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

Nuwer Lake Dam
Oregon County, Missouri
Mo. I.D. No. 30190

Sheet 2, Appendix D

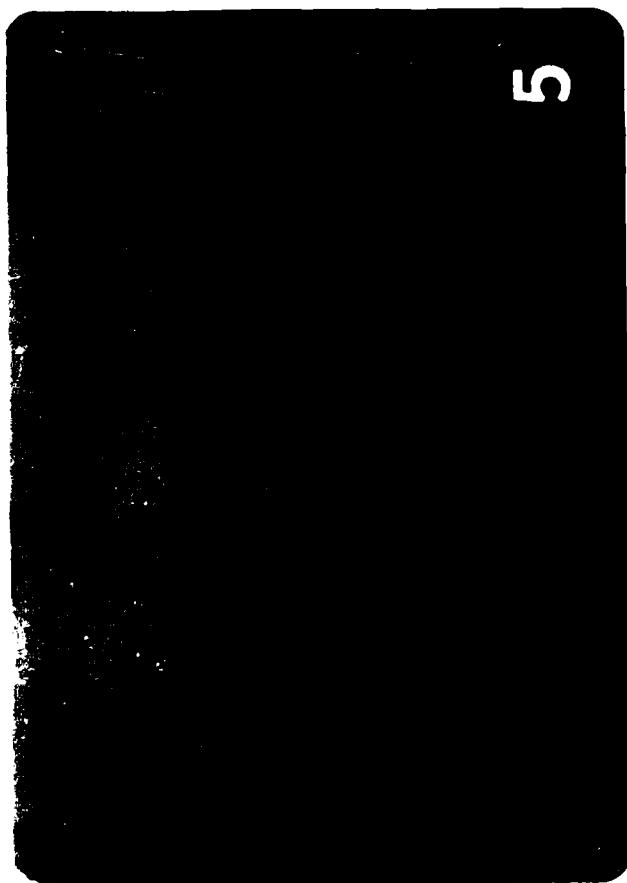




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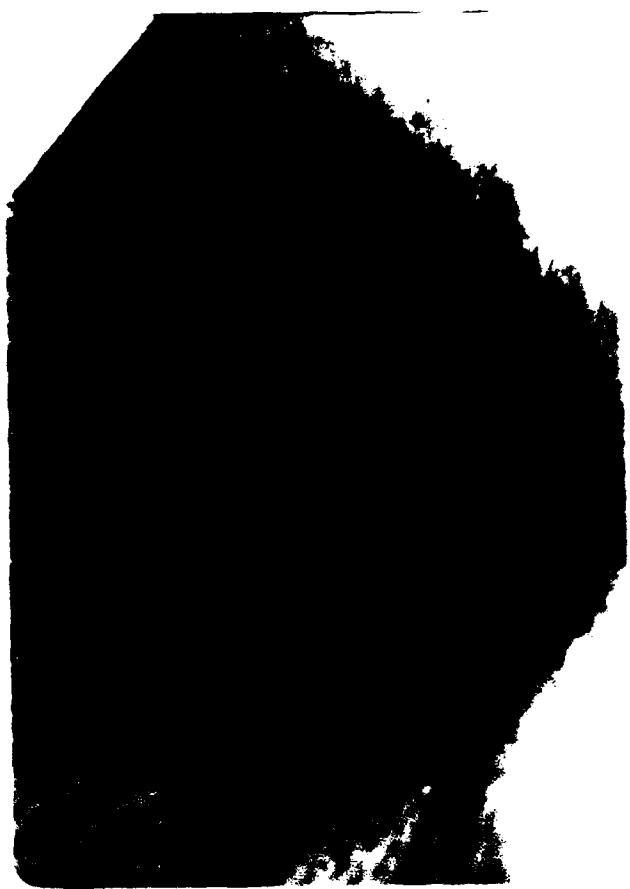
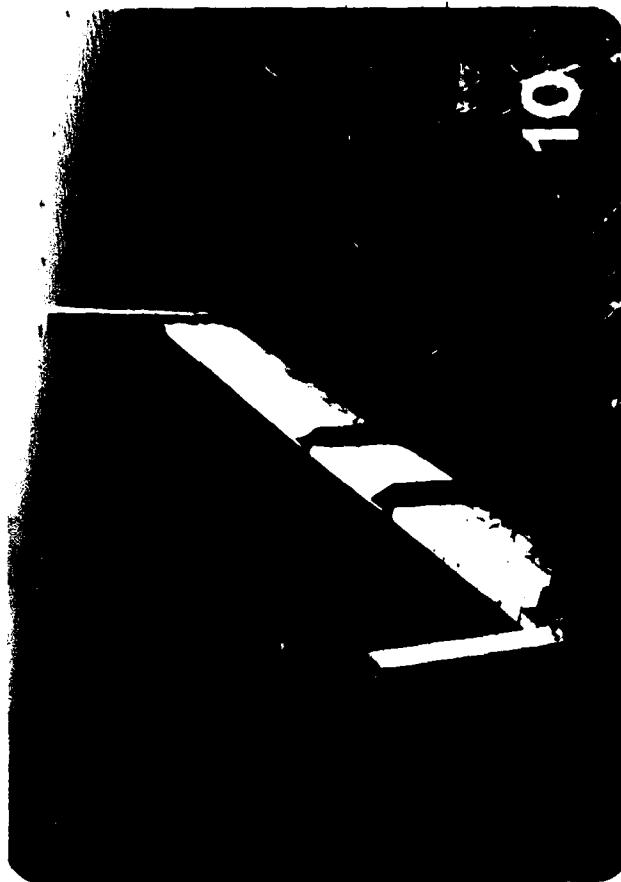
8

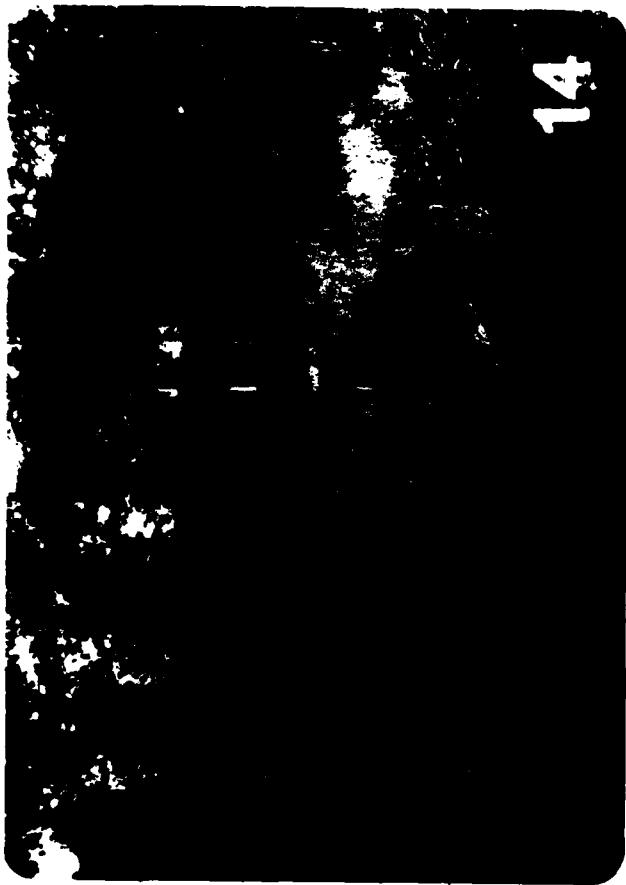


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